Mines and Minerals Division

Ontario Geological Survey
Open File Report 5640

Aggregate Resources Inventory of the Echo Bay–Bruce Mines Area and St. Joseph Island

District of Algoma

1988

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Ministry of
Northern Development
and Mines

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MINES AND MINERALS DIVISION

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Open File Report 5640

Aggregate Resources Inventory of the Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma

by

Staff of the Engineering and Terrain Geology Section,
Ontario Ministry of Northern Development and Mines

1988

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V.G. Milne

V.G. Milne, Director
Ontario Geological Survey

FOREWORD

The Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma, contain a number of sand and gravel deposits which were laid down during glacial times. This report and its accompanying maps delineate these deposits and provide additional information regarding their thickness, geological character and suitability for use as construction aggregate. The report also indicates which deposits possess the greatest potential for resource use, and discusses bedrock resource potential.

This report supplies valuable information which will be beneficial in resource planning.

V.G. Milne, Director
Ontario Geological Survey

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CONTENTS

Page

Abstract.. xv
Introduction.. 1
Location and Population................................... 2
Physiography and Surficial Geology........................ 4
Extractive Activity....................................... 9
Selected Sand and Gravel Resource Areas................... 9
Selected Sand and Gravel Resource Areas, Echo Bay-Bruce Mines Area (Map 2A)...................................... 12
  Selected Sand and Gravel Resource Area 1................ 12
  Selected Sand and Gravel Resource Area 2................ 14
  Selected Sand and Gravel Resource Area 3................ 15
  Selected Sand and Gravel Resource Area 4................ 17
  Selected Sand and Gravel Resource Area 5 and 6.......... 18
  Selected Sand and Gravel Resource Area 7................ 19
  Selected Sand and Gravel Resource Area 8................ 20
Selected Sand and Gravel Resource Areas, St. Joseph Island (Map 2B)... 21
  Selected Sand and Gravel Resource Area 9................ 21
  Selected Sand and Gravel Resource Area 10............... 22
  Sand and Gravel Resource Areas of Secondary Significance, Echo Bay-Bruce Mines Area (Map 2A) 26
  Selected Sand and Gravel Resource Areas of Secondary Significance, St. Joseph Island (Map 2B)............... 33
  Sand and Gravel Resource Areas of Tertiary Significance................................ 36
Bedrock Resource Potential................................ 37
Summary... 41
References.. 103
Appendix A - Purpose, Methodology and Data Presentation of the Aggregate Resources Inventory............................ 105
Appendix B - Suggested Additional Reading................. 122
Appendix C - Glossary..................................... 124
Appendix D - Geology of Sand and Gravel Deposits.......... 128

TABLES

1 - Total Sand and Gravel Resources, Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma............... 43

2- Sand and Gravel Pits, Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma................... 52

3 - Selected Sand and Gravel Resource Areas, Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma.......... 65

4 - Summary of Test Hole Data, Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma................... 69

5 - Summary of Geophysics Data, Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma................... 74

FIGURES

Page

1 - Key Map Showing the Location of the Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma Scale 1:1 584 000.................................... xv

2 - Bedrock Geology of the Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma. Scale 1:390 000.... 38

3a - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 79

3b - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 80

4a - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 81

4b - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 82

5a - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 83

5b - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 84

6a - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 85

6b - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 86

7a - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 87

7b - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 88

8a - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 89

8b - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 90

9a - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 91

9b - Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 92

10a- Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 93

10b- Aggregate Grading Curves, Echo Bay-Bruce Mines Area, District of Algoma.................................... 94

Page

11a - Aggregate Grading Curves, St. Joseph Island, District of Algoma.................................... 95

11b - Aggregate Grading Curves, St. Joseph Island, District of Algoma.................................... 96

12a - Aggregate Grading Curves, St. Joseph Island, District of Algoma.................................... 97

12b - Aggregate Grading Curves, St. Joseph Island, District of Algoma.................................... 98

13a - Aggregate Grading Curves, St. Joseph Island, District of Algoma.................................... 99

13b - Aggregate Grading Curves, St. Joseph Island, District of Algoma.................................... 100

14a - Aggregate Grading Curves, St. Joseph Island, District of Algoma.................................... 101

14b - Aggregate Grading Curves, St. Joseph Island, District of Algoma.................................... 102

MAPS (Back Pocket)

1A - Distribution of Sand and Gravel Deposits, Echo Bay-Bruce Mines Area, District of Algoma

1B - Distribution of Sand and Gravel Deposits, St. Joseph Island, District of Algoma

2A - Selected Sand and Gravel Resource Areas, Echo Bay-Bruce Mines Area, District of Algoma

2B - Selected Sand and Gravel Resource Areas, St. Joseph Island, District of Algoma

ABSTRACT

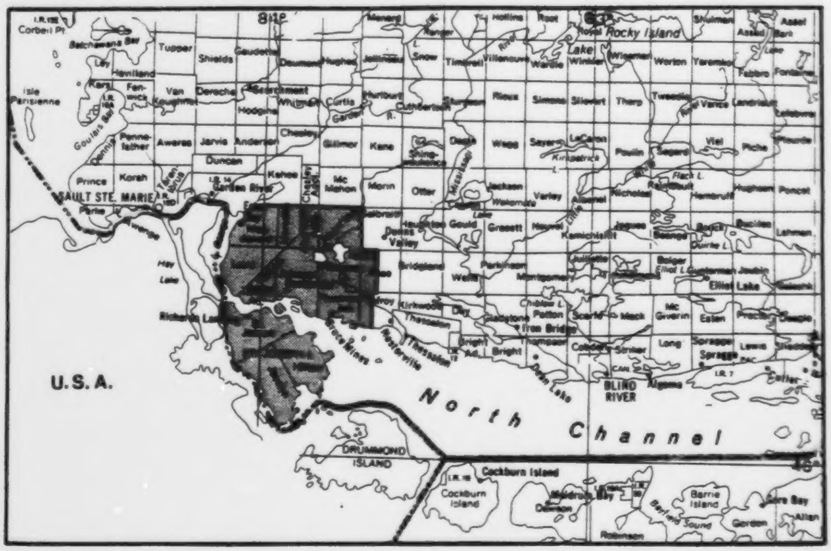

Figure 1 - Key Map Showing the Location of the Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma. Scale 1:1 584 000.

This report presents the results of a sand and gravel inventory in the Echo Bay-Bruce Mines Area and on St. Joseph Island in the District of Algoma. The report is based on a detailed field assessment undertaken in the autumn of 1986 and on information gathered in previous studies of the area. The investigation was conducted to delineate the aggregate resources within the area and to determine the quality and quantity of material available for extraction. This information will be used to help ensure sufficient aggregate resources are available for future use.

Ten Resource Areas of Primary Significance have been selected for possible resource protection. The deposits they contain are considered to be the best suited for extractive development within the report area. Selected Sand and Gravel

Resource Areas 1 and 2 consist of two ice-contact deposits and a kame deposit which have been traditional sources of aggregate in the Echo Bay-Bruce Mines Area. Two extensive beach deposits on St. Joseph Island are important sources of pit run and crushable material and have been selected as Primary Resource Areas 10a and 10b. Most of the remaining Selected Areas consist of kame or wave-modified ice-contact deposits, and represent valuable potential sources of good quality aggregate. The Ten Primary Resource Areas occupy a total of 12,400 acres (5000 ha) currently available for extraction and contain granular resources of approximately 680 million tons (620 million tonnes). In addition, a number of deposits have been selected for possible resource protection at the secondary level of significance. Although these deposits are generally not as significant as the Primary Resource Areas, they add considerably to the resource base of the area.

Selected Resource Areas are not intended to be permanent, single land use units. They represent areas in which a major resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection.

With the exception of Tarbutt and Meredith geographic townships, the townships in the report area appear to contain locally significant aggregate deposits. Care should be taken to ensure the continued availability of as much of the remaining resources as possible.

An alternative source of aggregate in the study area is bedrock-derived aggregate. The bedrock consists of a complex

array of metasedimentary and intrusive rocks of Precambrian age, and Paleozoic sandstone, shale and carbonates. Of the bedrock which underlies the area, the Nipissing diabase is considered the best suited for possible extractive development.

AGGREGATE RESOURCES OF THE ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA[1]

INTRODUCTION

The sand and gravel resources of the Echo Bay-Bruce Mines Area and St. Joseph Island, District of Algoma, were investigated by a two-person field party in the autumn of 1986. Although the results of this work would normally be released in an Aggregate Resources Inventory Paper, the Open File Report format is used here in order to make this information available as quickly as possible. The purpose and methodology used to prepare this report are essentially the same as those used for an Aggregate Resources Inventory Paper, and are presented in Appendix A. The format in which the information is presented on the maps is explained on the map legends and in the appendices.

Granular deposits related to glacial activity are widespread in the report area. The Primary Resource Areas discussed later in the text include the deposits which are considered the best suited for extractive development. A wide range of aggregate products can be produced from these deposits and their continued availability as sources of aggregate is important. It is essential that planning strategies recognize the value of these areas in land use plans.

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[1] This project was jointly funded by Sault Ste. Marie District, Northeastern Region, Ontario Ministry of Natural Resources, and the Ontario Geological Survey, Mines and Minerals Division, Ontario Ministry of Northern Development and Mines.

Manuscript approved for publication by Chief, Engineering and Terrain Geology Section, Ontario Geological Survey, February 27, 1988.

This report is published with the approval of V.G. Milne, Director, Ontario Geological Survey, Mines and Minerals Division, Ontario Ministry of Northern Development and Mines, Toronto.

LOCATION AND POPULATION

The report area is located east and southeast of the city of Sault Ste. Marie. The mainland study area lies along the North Channel and St. Joseph Channel of Lake Huron, east and south of Lake George. To the west, the study area is adjacent to the Canada - United States of America International Boundary. The report area occupies approximately 282,000 acres (114,000 ha) in the District of Algoma. The area is covered by the Echo Lake (41 J/12), St. Joseph Island (41 J/4), Bruce Mines (41 J/5), Munuscong Lake (41 K/1), Lake George (41 K/8 and 41 K/7), and Sault Ste. Marie (41 K/9) map sheets of the National Topographic System, at a scale of 1:50,000. In addition, General Map No. MCR 102 of the National Topographic System covers all of St. Joseph Island at this scale. This map sheet has been used in the preparation of the accompanying maps for St. Joseph Island.

The report area has been divided into two map areas. The part of the project area which is on the mainland is referred to as the "Echo Bay-Bruce Mines Area" and is shown on maps with the same name. St. Joseph Island is shown on separate maps, entitled "St. Joseph Island".

The Echo Bay-Bruce Mines Area consists of five incorporated township municipalities and one unorganized township. The townships of Macdonald, Meredith and Aberdeen Additional, Laird, Tarbutt and Tarbutt Additional, and Johnson are made up of the geographic townships bearing the same names. The township of Plummer Additional includes Plummer and Plummer Additional geographic townships and parts of Rose and Lefroy geographic townships. Aberdeen Township is the only township in the project area without organized municipal structure. St. Joseph Island consists of three incorporated township municipalities: St. Joseph, Jocelyn and Hilton.

The total population of the organized township municipalities in the study area in 1985 was 5274 (Ontario Ministry of Municipal Affairs 1987), whereas in 1975 it was 4818 (Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1976). These figures indicate a population increase of approximately nine percent over a ten year period, indicating slow but steady growth in the area. In the unorganized township of Aberdeen, the population is sparse. Bruce Mines is the major population centre on the mainland, with a population of 620 in 1985 (Ontario Ministry of Municipal Affairs 1987). Smaller settlements including Echo Bay and Desbarats also serve the area. The hamlet of Richards Landing and the village of Hilton Beach are the main population centres on St. Joseph Island. In 1985, Hilton Beach had a population of 223 (Ontario Ministry of Municipal Affairs 1987).

Economic activity in the area is related to farming, tourism and the forest industry. Maple syrup is produced, especially on the island. Because many residents of the Echo Bay-Bruce Mines Area and St. Joseph Island hold jobs outside of the study area, primarily in the City of Sault Ste. Marie, the area serves an important residential function (St. Joseph Island

Planning Board and Sawchuk and Peach Architects-Planners 1973; Echo Bay Planning Board 1979).

Access to the area is provided by King's Highway 17, the route of which follows the shore of the mainland. Secondary Highways 638 and 561 run approximately east-west and north-south respectively, supplying additional road access in the Echo Bay-Bruce Mines Area. Access to St. Joseph Island is provided by a road bridge just south of King's Highway 17 on Secondary Highway 548. Secondary Highway 548 circles the Island. On the mainland and on the island, networks of gravel-surfaced township roads, as well as logging and other private roads, provide additional access. Rail service on the mainland is provided by the Canadian Pacific Railway.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of surficial materials in the project area are related to the last major advance and withdrawal of a continental ice sheet during the Wisconsinan Substage of the Pleistocene Epoch - a period of time known informally as the "Great Ice Age". This time period lasted from approximately 100 000 to 7000 years ago, and was marked by the repeated advance and melting of extensive continental ice sheets.

Glacial deposits in the project area are underlain by bedrock of Precambrian and Paleozoic age. Precambrian bedrock, consisting of a complex array of metasedimentary and intrusive rocks, is exposed throughout much of the mainland study area, and in the northern part of St. Joseph Island. Paleozoic sandstone underlies a small area in the northeastern part of the Echo Bay-Bruce Mines Area. Most of St. Joseph Island is underlain by Paleozoic sandstone, shale and carbonates which only outcrop along the northern rim of the island. The nature of these rocks has been described in detail by Liberty (1967), Frarey (1977), Springer (1977), Giblin and Leahy (1979), Bennett (1982) and Russell (1985, 1987). For further information on the bedrock geology of the area, the reader is referred to these reports.

The bedrock is primarily responsible for the "rock knob" and "rock ridge" physiography of the Echo Bay-Bruce Mines Area (McQuay 1980; VanDine 1980a,b). This topography is largely the result of differential weathering between the various rock types, as well as erosion by glacial ice as it moved over the area. In contrast, the Paleozoic bedrock underlying St. Joseph Island is covered by thick drift and only outcrops occasionally. Glacial and postglacial deposits are the dominant surficial material on the island, and are responsible for the considerable topographic relief found there. Especially prominent is a central high hill, made up entirely of drift. This hill is known locally as "the Mountain" and will be referred to as such in this report.

The core of the Mountain appears to be a thick sequence of silt and sand which may be of glaciofluvial outwash, possibly deltaic origin (Karrow, in press). This silt and sand sequence appears to only occur in the Mountain. Although the exact age and origin of these sediments is unknown, they predate the overlying layer of till.

Till is the oldest widespread surficial sediment in the report area (Boissonneau 1968; Karrow, in press). It is predominantly a bouldery silty sandy till, although a compact silty clay till was also noted. The till was deposited as a thin veneer over bedrock and existing deposits by glacial ice which advanced in a south to southwesterly direction (McQuay 1980; VanDine 1980a,b). On St. Joseph Island, till was also deposited in the form of drumlins and moraine ridges, especially in the northwestern portion of the island (Karrow, in press). Till is not well suited for aggregate use as it often contains excess fines and abundant oversize clasts. In places this material may be acceptable for use as fill.

During deglaciation, ice-contact stratified drift deposits were laid down in close proximity to the ice front as it melted back to the north. These deposits are widespread in the Echo Bay-Bruce Mines Area. Some deposits occur as small patches of sand and gravel positioned on the south side of rock knobs, and contain only limited resources of aggregate. More extensive ice-contact deposits also occur within the study area, notably east of Echo Bay, south of MacLennan, and west of Eleanor Lake. Several pits have been developed in these deposits. On St. Joseph Island the ice-contact deposits are less extensive and are restricted, for the most part, to the northwestern part of the island. An esker was formed south of Richards Landing as the ice melted back. Several small kame deposits were also formed in the vicinity of the esker, and in the Desjardins Bay area.

The sole outwash deposit in the study area is located in Meredith geographic township. Sand was laid down in a bedrock depression by meltwaters flowing from the ice margin towards the Lake Huron basin.

Glacial Lake Algonquin formed as meltwater was dammed between the ice, positioned just north of the study area, and higher ground to the south (Karrow, in press). Only the high knobs and ridges on the mainland and the Mountain on St. Joseph Island were not submerged. The glacial lake waters washed the fine materials from previously deposited sediments and carried them offshore, redepositing medium to fine sand, silt and clay in areas of lower elevation throughout the report area. In areas of deeper water in the lake, such as the Thessalon River valley, the lowland areas near the shore of the mainland, and the northwestern part of St. Joseph Island, deposits of silt and clay were laid down. Some of the clay has a reddish colour which is caused by iron staining. In places the clay overlies ice-contact deposits.

Lacustrine shoreline influence is apparent in the Echo Bay-Bruce Mines Area and on St. Joseph Island. In the high-energy, shallow waters along the shoreline of glacial Lake Algonquin, till and ice-contact deposits were reworked to produce a variety of beach forms and beach deposits. On the mainland, modified ice-contact deposits capped by a coarse gravel lag layer, and moderately well worked beach deposits occur. On

St. Joseph Island the deposits are better developed and are more extensive with the most prominent beach feature being a gravel deposit which encircles the Mountain. This deposit contains a large volume of well sorted, rounded, clean, crushable gravel formed from wave reworking of till by the highest level of glacial Lake Algonquin. As the lake level lowered from a maximum elevation of 930 feet (280 m), regressive beach and bar deposits were formed (Karrow, in press), but in general, these deposits are not as well developed as the higher deposit. The material is poorly to moderately sorted, subrounded, and may contain some fines. The beach and wave-washed deposits on the island have been a traditional source of gravel.

Following the draining of glacial Lake Algonquin the waters of glacial Lake Nipissing inundated the study area. A new shoreline was eroded some 65 feet (20 m) above the present lake level (Karrow 1982). On the island, beaches formed by the Lake Nipissing shoreline generally contain finer material than is found in Lake Algonquin beaches (Karrow, in press). Sand sheet deposits, which are formed in the transitional zone between deep and shallow water, are found in low areas below the glacial Lake Nipissing shoreline (Karrow, in press).

On St. Joseph Island, during the time of glacial Lake Nipissing, wind action reworked lacustrine sand present above the shoreline into dunes. A belt of dune sand extends from east of Harmony to Hilton Lake. Smaller eolian deposits are located north of Hilton Lake and west of Rains Lake.

In the period since the disappearance of the ice sheet and the lowering of lake waters to present day levels, erosion has been minimal in the project area. Organic deposits have developed in depressions in the land surface, and some alluvial deposits have been laid down along water courses (McOuay 1980; VanDine 1980a,b).

EXTRACTIVE ACTIVITY

At the time of field investigation, 158 sand and gravel pits located throughout the report area were identified. These pits are worked on a demand basis. Many of the pits had been inactive for a considerable period of time, while some appeared to have been worked recently. Some of the pits were located in small deposits and were near depletion. Other pits had been opened to supply only low-specification borrow material. The sand and gravel pits are plotted on the maps which accompany this report, and are described in Table 2.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Maps 1A and 1B for the Echo Bay-Bruce Mines Area and St. Joseph Island, respectively, show the deposits which contain granular materials. These deposits occupy a total of approximately 62,000 acres (25 000 ha) and contain an original resource tonnage of 1860 million tons (1690 million tonnes). Many of these deposits have limited potential for extractive development for one or more of the following reasons: limited amount of available resources; poor material quality; limited accessibility. Only the most significant resources have been suggested for possible resource protection.

The selected sand and gravel resource areas are shown on Maps 2A and 2B. Ten areas have been selected for possible resource protection at the primary level.

On the mainland, an ice-contact deposit and a kame deposit have been designated as Selected Sand and Gravel Resource Area nos. 1a and 2. These deposits have been traditional sources of crushable gravel and are important aggregate resources within the Echo Bay-Bruce Mines Area. Most of the remaining Primary Resource Areas on Map 2A are wave-modified ice-contact deposits which contain valuable resources of sand and gravel. Many of these modified ice-contact deposits are considered to be well suited for the extraction of pit run aggregate, and are potential sources of crushable gravel. Aggregate of ice-contact origin is often suitable for road building and construction uses even though it may show a wide variation in grain size and contain excessive amounts of fine material.

On St. Joseph Island two extensive beach deposits have been selected as Primary Resource Areas. Selected Sand and Gravel Resource Area 10a contains significant amounts of crushable gravel. The material in Area 10b is more variable, and is suitable for a number of aggregate uses. A small kame deposit has also been selected at the primary level of significance. The deposit contains good quality crushable gravel and represents an important aggregate source.

The ten Selected Sand and Gravel Resource Areas of Primary Significance occupy a total area of 13,300 acres (5400 ha). Cultural constraints and previous extraction reduce the area currently available to 12,400 acres (5000 ha). The selected areas contain possible sand and gravel resources of approximately 680 million tons (620 million tonnes).

A number of ice-contact stratified drift and glaciolacustrine beach deposits scattered throughout the report area, and sections of an esker on St. Joseph Island, have been selected at the secondary level of significance. In terms of aggregate quality or the amount of available resources these deposits have less value for extraction than the primary areas. However, they do provide important alternative aggregate sources that add significantly to the resource base of the report area.

With the exception of Tarbutt and Meredith geographic townships, the townships within the report area appear to contain substantial aggregate resources that should be sufficient to meet local requirements for a considerable period of time.

Based on field observations, and Ministry of Transportation data including petrographic examinations, the aggregate within the report area appears to be hard and durable, and suitable for a wide range of road-building and general construction applications. Use of the material in portland cement concrete may be limited by the presence of argillite, greywacke and sandstone clasts of the Huronian Supergroup. These clasts are potentially alkali-reactive (Rogers 1985), and testing of the aggregate is strongly recommended prior to use in concrete products.

Selected sand and gravel resource areas are not permanent, single land use units. They represent areas in which a major resource is believed to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection.

SELECTED SAND AND GRAVEL RESOURCE AREAS, ECHO BAY-BRUCE MINES AREA (MAP 2A)

Selected Sand and Gravel Resource Area 1

Selected Sand and Gravel Resource Area 1 is an extensive ice-contact deposit which is located immediately east of Echo Bay in northwestern Macdonald geographic township. The internal structure of this deposit is variable and includes features which suggest an ice-contact, possibly deltaic, origin. The area has been divided into two segments (labelled 1a and 1b on Map 2A) based on suspected differences in the thickness of the deposits.

Resource Area 1a contains large potential resources of sand and gravel. Pit no. 2 is located in Area 1a, just north of Secondary Highway 638. This pit has been the site of large scale extractive activity in the past, and has been a traditional source of aggregate in the report area. At the time of the field investigation, face heights ranged from 50 feet (15 m) in the southwestern part of the pit to 80 feet (24 m) in the northern part. The gravel content in the pit faces ranged from 30 to 60 percent. A sample taken from the pit contained 45 percent gravel (Figure 3a). The faces generally exposed angular, fine to coarse gravel with a variable, fine to coarse silty sand matrix. Oversize material was common. The greatest concentrations of crushable gravel were located at the northeastern end of the pit where the gravel was coarse to bouldery. Silt and clay seams were noted, and in places the coarse gravel was silt coated. A highly compact silty clay till was also observed in the western and northern parts of the pit.

Test hole ST-TH-1 was excavated in Area 1a and exposed 11 feet (3.4 m) of fine to coarse gravel with dirty coarse sand (Table 4). A sample of the material contained 68 percent gravel, 30 percent sand and 2 percent fines (Figure 9a).

Ministry of Transportation data indicate that material extracted from this pit is suitable for a range of construction products including granular base course, 16 mm crushed type A stone, Hot-Laid (H.L.) No. 4 stone and structural concrete stone. Selective extraction and sand control will be required in sections during crushing operations. Oversize material is abundant in Area 1a, and should be removed or crushed in a primary crusher. Sand gradations vary from fine to coarse and will require blending for the production of hot-laid sand. Silt and clay seams should be avoided during extraction.

Resource Area 1b is an extension of Resource Area 1a. No extraction has taken place in this hummocky, ice-contact deposit and subsurface information is lacking. A small exposure located near a kettle depression revealed fine to coarse gravel with fine to coarse sand. In places, the gravel appeared to be suitable for crushing. Material which is similar in quality to that exposed in pit no. 2 is expected to exist in this presently undeveloped deposit.

Resource Areas 1a and 1b occupy an available area of 305 acres (123 ha). Assuming an average thickness of 60 feet (18 m) for Area 1a, and 20 feet (6 m) for Area 1b, available aggregate resources are estimated to be 41 million tons (37 million tonnes). Resource Area 1a is bisected by Secondary Highway 638. Despite such factors as the presence of oversize material and excess fines, and the need for sand control and blending, consideration should be given to protecting as much of Area 1 as possible.

Selected Sand and Gravel Resource Area 2

A kame deposit located south of MacLennan in Tarbutt Additional geographic township has also been selected at the primary level of significance. Significant volumes of crushable gravel have been extracted from the deposit.

Five pits with faces ranging from 5 to 40 feet (1.5 to 12 m) high have been established in the deposit. In pit no. 49, the kame gravels are obscured by a thick layer of lacustrine fine sand. This pit is largely depleted and the remaining aggregate shows a wide variation in grain size. The materials exposed in pit nos. 51 to 54 are predominately fine to coarse gravels. In places the gravel is coated with fines. Oversize material is common and the use of a primary crusher in these pits would be beneficial. A stockpile of crushed gravel was present in pit no. 54. A sample containing 66 percent gravel, 29 percent sand and 5 percent fines was taken from pit no. 52 (Figure 6a). The deposit depth is irregular, as indicated by a bedrock knob which protrudes into the centre of the deposit.

Data from the Ministry of Transportation indicate that the aggregate in the deposit is generally suitable for such uses as 16 mm crushed Type A stone, granular base course, as well as H.L. No. 4 stone. The sand fraction of the aggregate requires blending for use in asphaltic sand products and sand control may be necessary during crushing operations.

Resource Area 2 occupies 140 acres (57 ha), of which 80 acres (32 ha) are considered to be available for extraction. Assuming an average deposit thickness of 20 feet (6 m), aggregate resources are estimated to be 4 million tons (4 million tonnes). Access to the area is excellent as King's Highway 17 crosses the deposit.

Selected Sand and Gravel Resource Area 3

Selected Sand and Gravel Resource Area 3 is located along Secondary Highway 638, west and southwest of Eleanor Lake in southern Aberdeen Additional geographic township. The Resource Area consists of two wave-modified ice-contact deposits labelled 3a and 3b on Map 2A. The deposits flank a bedrock ridge to the north.

Two pits with faces ranging from 20 to 60 feet (6 to 18 m) have been developed in Area 3a. Faces in pit no. 12 revealed a distinct coarse gravel lag layer overlying fine to coarse angular gravel and fine to coarse sand. Field estimates of gravel contents were as high as 60 percent. A considerable number of boulders were also noted in the pit. Oversize material must be removed or crushed to suitable size ranges before it can be used as aggregate. A sample containing 54 percent gravel, 44 percent sand, and 2 percent fines was taken from the pit (Figure 4a). Data from the Ministry of Transportation indicate that material in the pit is suitable for use in granular base course, asphalt and structural concrete. Selective extraction and sand control may be required in sections to produce crushed stone products. Sand gradations vary from being acceptable to containing excess coarse material, and blending will be required to produce hot-laid sand.

Pit nos. 8 and 10 are located in Area 3b. Face heights in the pits ranged from 10 to 15 feet (3 to 5 m), and gravel content ranged from 30 to 50 percent. Faces in pit no. 8 consisted largely of coarse gravel which is likely to be suitable for use in crushed stone products with appropriate processing. A Ministry of Transportation power equipment investigation northwest of pit no. 10 within Area 3b, indicated that the aggregate is acceptable for 16 mm Crushed Type A stone, and H.L. No. 4 stone with appropriate processing. Blending is required for asphaltic sand products.

Resource Areas 3a and 3b occupy a total area of 500 acres (202 ha). Previous extraction and cultural constraints have reduced the area currently available to 335 acres (136 ha). Assuming an average deposit thickness of 40 feet (12 m) for Area 3a, and 15 feet (5 m) for Area 3b, resources of sand and gravel are estimated to be 20 million tons (18 millon tonnes). Secondary Highway 638 provides access to the Resource Areas.

Selected Sand and Gravel Resource Area 4

Selected Sand and Gravel Resource Areas 4a and 4b are ice-contact deposits located in Johnson Township. Resource Area 4a is situated south of King's Highway 17, southeast of Desbarats. Recent extraction in pit no. 72 revealed a 10- to 20-foot (3 to 6 m) face of fine to coarse angular gravel occurring in lenses over bedrock. The eastern face revealed fine silty lacustrine sand overlying coarse crushable gravel. Gravel content ranged from 40 to 50 percent. Although no quality data is available for the pit, it is likely that the lenses of coarse gravel are suitable for the production of crushed stone products, if sand control and selective extraction measures are employed.

Area 4b is located southwest of Caribou Lake. It is a smaller deposit than Area 4a and the material is draped on the side of a rock outcrop. Pit no. 68 has been opened in Area 4b and exhibits a 10- to 20-foot (3 to 6 m) face of ice-contact material ranging in size from silt to boulders. A sample from the pit contained 48 percent gravel, 51 percent sand and 1 percent fines (Figure 7a). With selective extraction and sand control measures, the coarse gravel within the pit may be used for crushing. Boulders should either be removed, or crushed and used for aggregate. Blending would be required for asphaltic sand products. Material similar to that exposed in the pit is expected to exist in the undeveloped parts of the deposit.

Areas 4a and 4b have a combined available area of 130 acres (53 ha) representing a resource tonnage of 5 million tons (4 million tonnes), based on an average thickness of 15 feet (5 m). Gravel-surfaced township roads serve both areas.

Selected Sand and Gravel Resource Areas 5 and 6

Selected Sand and Gravel Resource Areas 5 and 6 are wave-modified ice-contact deposits located west and east of Rock Lake in southern Aberdeen Township. Both deposits flank bedrock and extend southward into Plummer Additional Township.

Pit no. 24 is located in Selected Resource Area 5. Field examination revealed that the material is draped on the side of a rock outcrop. The 25- to 30-foot (8 to 9 m) exposure revealed a variable gravel content, ranging from 30 to 60 percent fine to coarse gravel. Coarse crushable gravel was concentrated within a modified lag layer which overlay fine to coarse angular gravel and medium to coarse sand. Boulders and silt seams were common in the pit. Ministry of Transportation data indicate that with appropriate processing the material in the pit can be used in crushed stone products.

Selected Resource Area 6 contains material which was deposited between bedrock highs. The 15- to 20-foot (5 to 6 m) faces in pit no. 33 contained subangular to angular, fine to coarse gravel with medium to coarse sand. Oversize clasts were noted. A sample taken from the pit face contained 51 percent gravel, 47 percent sand and 2 percent fines (Figure 5a). Data from the Ministry of Transportation indicate that, with strict sand control and selective extraction, the material in the pit is suitable for use in granular base course and H.L. No. 4 stone. Sand gradations vary from being suitable to containing excess coarse material. Blending will be required to produce asphaltic sand products.

Test hole ST-TH-7 was excavated in Area 6, and exposed 11 feet (3.4 m) of fine to coarse gravel. A sample from the test hole contained 53 percent gravel, 44 percent sand and 3 percent fines (Figure 10a). Test hole ST-TH-6 revealed similar material with a lower gravel content. Similar quality aggregate likely exists in the undeveloped parts of the deposit.

Resource Area 5 and 6 occupy an estimated available area of 230 acres (93 ha) in Aberdeen Township and Plummer Additional Township. The Resource Areas are estimated to contain 9 million tons (8 million tonnes) of sand and gravel. Selected Resource Area 5 is accessible from a network of gravel-surfaced roads. Selected Resource Area 6 is readily accessible from Secondary Highway 561.

Selected Sand and Gravel Resource Area 7

Area 7 is an ice-contact deposit in central Plummer geographic township. The deposit flanks a bedrock ridge to the north. Two pits have been opened in the resource area. Lenses of fine to coarse gravel were exposed in the 15-foot (5 m) face of pit no. 95. Seams of silt and clay were observed and should be avoided. Ministry of Transportation files indicate that material from the pit has been used in the past for Granular Base Course (G.B.C.) B, 16 mm Crushed Type A and H.L. No. 8 stone, with suitable processing. The fine aggregate in this pit also has potential for use as asphalt sand if it is blended to produce a suitable gradation. Data from a Ministry of Transportation power equipment investigation near pit no. 95 indicate that the material has fairly good crushing potential if selection and sand control measures are employed. The results of seismic line ST-GT-4 undertaken north of pit no. 96 indicate that aggregate extends to a depth of approximately 11 feet (3.4 m) to bedrock.

Resource Area 7 occupies 280 acres (113 ha), of which 210 acres (85 ha) are considered suitable for extraction. Assuming an average thickness of 15 feet (5 m), available aggregate resources are estimated to be 8 million tons (7 million tonnes). A gravel-surfaced township road crosses over the Resource Area and provides excellent access.

Selected Sand and Gravel Resource Area 8

Selected Sand and Gravel Resource Area 8 is a wave-modified ice-contact deposit located northeast of Cloudslee in northwest Lefroy geographic township. Pit no. 108 has been established in the deposit. The 15- to 20-foot (5 to 6 m) faces in the pit expose well-stratified fine to coarse gravel with a field estimated gravel content ranging from 30 to 50 percent. Ministry of Transportation information is not available for this deposit. Lenses of coarse gravel within the pit are potential sources of crushable material if sand control and selective extraction measures are employed. The Resource Area is a valuable source of aggregate because coarse material is scarce in the remainder of the township.

Resource Area 8 has an available area of 55 acres (22 ha). With an average deposit thickness of 15 feet (5 m), estimated resources of sand and gravel are 2 million tons (2 million tonnes). Good access to the Resource Area is provided by gravel surfaced roads.

SELECTED SAND AND GRAVEL RESOURCE AREAS, ST. JOSEPH ISLAND (MAP 2B)

Selected Sand and Gravel Resource Area 9

Selected Sand and Gravel Resource Area 9 is a kame deposit located southwest of Richards Landing in St. Joseph Township. The material contained in this resource area is variable (as is typical of a kame deposit) although of good quality. Although the deposit is small in size, it adds considerably to the resource base of the township.

Three pits have been developed in the Resource Area. Pit no. 114 exposes 8 to 10 feet (2 to 3 m) of clean medium sand with minor fine to medium gravel. In pit no. 113, 10- to 15-foot (3 to 5 m) faces were noted. One face exposed openwork fine gravel interbedded with coarse sand. Another face revealed fine to coarse gravel in a coarse sand matrix. A minor amount of oversize clasts were noted. The bedding was variable, and occasionally the gravel clasts were coated with fines. A sample taken from this face contained 72 percent gravel, 27 percent sand

and 1 percent fines (Figure 11a). The aggregate appears to be suitable for both pit run and crushed stone products. Data from the Ministry of Transportation indicates that oversize material should be removed or crushed. Selection and sand control may be required in places to produce crushed stone products. The sand requires blending in order to be used in hot laid asphalt products.

The third pit is worked in two sections. The 4- to 10-foot (1.2 to 3 m) faces of the northern part of pit no. 112 exposed predominantly fine to coarse gravel. In the southern section, 4 to 8 feet (1.2 to 2 m) of clean medium sand was noted. Water was observed on the pit floor. The Ministry of Transportation reports that selective extraction and sand control measures would be required to produce crushed aggregate products.

Resource Area 9 occupies 57 acres (23 ha) of which 54 acres (22 ha) are considered to be currently available for extraction. Assuming an average deposit thickness of 12 feet (4 m), sand and gravel resources are estimated to total 2 million tons (2 million tonnes). Access to the area is provided by gravel-surfaced township roads.

Selected Sand and Gravel Resource Area 10

Selected Sand and Gravel Resource Area 10 consists of two extensive beach deposits. Parts of these deposits are located in all three townships on the island. These deposits contain significant amounts of aggregate and have been traditional sources of sand and gravel on St. Joseph Island. Resource Area 10a is a thick deposit which encircles the Mountain. Resource

Area 10b, located east of the Mountain, is of more variable thickness. Both deposits contain material suitable for a variety of aggregate products.

Several large pits have been excavated in Area 10a. Pit no. 131 is worked in several faces ranging in height from 10 to 25 feet (3 to 8 m). The material exposed in this pit consisted of well rounded, fine to coarse gravel interstratified with medium to coarse sand layers. Features typical of a well developed beach were noted, such as imbrication and openwork structure gravel. A sample taken from pit no. 131 contained 48 percent gravel, 51 percent sand and 1 percent fines (Figure 12a). Seismic line ST-GT-7 indicates that aggregate may extend to a considerable depth below the pit floor (Table 5; Map 1B). Ministry of Transportation files indicate that material from this pit has been used in the past for G.B.C. A and B, and 5/8 inch crushed stone. A lack of fine material in sections of the pit may result in compaction problems in some aggregate products. The sand appears to be suitable for use in hot laid asphalt products.

The faces of pit no. 138 reveal 10 to 20 feet (3 to 6 m) of well imbricated and sometimes openwork beach material. The well rounded, fine to coarse gravel interstratified with fine to coarse sand is suitable for crushed stone and pit run products. An appreciable amount of oversize material, which must be removed or crushed, was noted in pit no. 138. A sample taken from pit no. 138 contained 56 percent gravel, 43 percent sand and 1 percent fines (Figure 12a). Aggregate may extend to a significant depth below the pit floor, as indicated by seismic line ST-GT-9. Data from the Ministry of Transportation indicate that sand control measures may be required when crushing material from some sections of the pit. Similarly, a lack of fine materials may lead to compaction problems in some aggregate products. The sand requires blending for use in hot laid asphalt aggregate.

The 4- to 10-foot (1.2 to 3 m) faces in pit no. 139 exposed fine to coarse gravel in a medium to coarse sand matrix. Some of the coarse material was in the oversize range. A primary crusher could be employed to make use of this material. Water was noted in places on the pit floor, and may limit the depth of extraction. Ministry of Transportation data indicate that in sections of the pit, selective extraction and sand control may be required for crushing operations. Blending is required in order to use the sand in hot laid asphalt products.

Resource Area 10a also contains a number of smaller pits. In pit nos. 130, 132, 133 and 134, face heights ranged from 5 to 20 feet (1.5 to 6 m). In general, these pits contained less gravel than the pits described previously. Fine to coarse gravel in a medium to coarse sand matrix was noted, with varying amounts of oversize clasts. Pit nos. 130, 132 and 134 contained little oversize material, while pit no. 133 contained over 20 percent. The material in the pits appeared to be suitable for pit run and crushed stone products although selective extraction and sand control may be required in pit nos. 132 and 134.

The characteristics typical of a beach deposit (see Appendix

D) are not as well developed in Resource Area 10b as they are in Resource Area 10a. The material in Resource Area 10b is subrounded to subangular, and moderately sorted. Several pits are located in this deposit. Pit no. 147 had 10- to 12-foot (3 to 4 m) faces showing fine to coarse gravel in a clean coarse sand matrix. In pit no. 148, the crushable gravel appeared to be restricted to the upper 10 feet (3 m) of the northern end of the pit. This fine to coarse openwork gravel was stratified. Below the gravel, stratified medium to coarse sand was underlain by silt. A sample from this pit contained 55 percent gravel, 44 percent sand and 1 percent fines (Figure 13a). The 6- to 7-foot (1.8 to 1.9 m) faces in pit no. 153 exposed fine to coarse gravel in a clean, coarse sand matrix. Water may limit the depth of extraction in pit nos. 148 and 153. In pit nos. 156, 6- to 30-foot (1.8 to 9 m) faces were noted, containing well imbricated, openwork, fine to coarse gravel, interstratified with medium to coarse sand. Boulders and cobbles were present in the upper layers. Pockets of clean medium sand were also noted. A sample from this pit contained 48 percent gravel, 49 percent sand and 3 percent fines (Figure 13a). The oversize material could be crushed in a primary crusher. Faces in pit no. 155 exposed 4 to 10 feet (1.2 to 3 m) of medium to coarse sand with minor fine gravel.

Data on file at the Ministry of Transportation indicate that compaction may be a problem in some products produced from pit no. 156, because of a lack of fines. Material from pit nos. 147, 148, 153 and 156 appears to be suitable for pit run and crushed stone products. Selective extraction and sand control measures may be required during crushing operations using material from these pits. Based on Ministry of Transportation data, blending would be required in order to use the sand from pit nos. 147, 148 and 156 in hot laid asphalt products. Although no Ministry of Transportation data ia available for pit no. 155, the material in the pit is expected to be suitable for use in pit run products.

A test hole excavated in Selected Resource Area 10b revealed 3 feet (1 m) of clean coarse sand with minor fine gravel over clay. Although the depth of usable aggregate in Area 10b is variable, the sand and gravel resources contained within this deposit have excellent potential for use as aggregate.

Approximately 11,000 acres (4450 ha) are currently available for extraction in Resource Area 10. Assuming an average depth of 30 feet (9 m) for Area 10a, and 15 feet (5 m) for Area 10b, aggregate resources are estimated to be 590 million tons (540 million tonnes). Selected Resource Areas 10a and 10b are readily accessible via gravel-surfaced township roads which branch off Secondary Highway 548.

SELECTED SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE, ECHO BAY-BRUCE MINES AREA (MAP 2A)

A number of deposits scattered throughout the report area are recommended for resource protection at the secondary level. They include glaciolacustrine beach and ice-contact stratified drift deposits. Many of these deposits have limitations for development in terms of size, thickness and/or aggregate quality, but still have value for local use when transport distance is more important than aggregate quality.

Three undifferentiated ice-contact stratified drift deposits in Macdonald, Meredith and Aberdeen Additional Township have been selected for secondary resource protection. The material contained in these deposits is variable because of their ice-contact origin. In pits 3, 7 and 9, which are located in these deposits, gravel distribution was irregular and silt seams were present. Gravel contents ranged from 20 to 60 percent. A sample taken from pit no. 7 contained 53 percent gravel, 46 percent sand and 1 percent fines (Figure 3a). Fine to medium gravel was the dominant material in all pits, however, coarse crushable gravel also occurred in sporadic lenses or pockets. Ministry of Transportation data indicate that the coarse aggregate from pit no. 9 has been used for concrete, asphalt and granular base course stone. Selective extraction and sand control measures are required in some sections of the pit for crushing operations. The finer material in the pit appears to be well suited for pit run products for local road-building and construction projects.

In Aberdeen Township, two deposits of ice-contact origin have been selected at the secondary level. The deposits are located north of Rock Lake and south of Bass Lake. The deposit located north of Rock Lake contains three pits. Pit nos. 22 and

23 have face heights ranging from 40 to 50 feet (12 to 15 m). Both pits have approximately 5 feet (1.5 m) of silty fine lacustrine sand at the top of the faces. Below the lacustrine sand, the faces expose chiefly medium to coarse sand interstratified with fine to medium gravel. Field estimates place gravel content at 10 to 20 percent. In places, bedrock restricts the depth of extraction in pit no. 22. A sample taken from pit no. 22 contained 21 percent gravel, 76 percent sand and 3 percent fines (Figure 4a). Medium to coarse gravel was observed on the floor of the pit, indicating the possibility that the aggregate coarsens with depth. Low specification aggregate such as G.B.C. C and fill may be the most readily available products from these pits. Minor amounts of crushed stone may be available from these pits if selective extraction and sand control measures are employed. Blending would be required to produce hot-laid sand products.

Two pits have been opened in the ice-contact deposit south of Bass Lake. During the field investigation of pit no. 14, 15- to 20-foot (5 to 6 m) faces and a gravel content of between 20 and 30 percent were noted. The presence of a beach lag layer containing coarse crushable material overlying a fan-like feature consisting primarily of fine aggregate indicates the deposit was modified by wave action following its initial deposition in an ice-contact environment. A sample from the pit face revealed 30 percent gravel, 69 percent sand, and 1 percent fines (Figure 4a). Test hole ST-TH-5 excavated in the floor of pit no. 14 revealed an additional 12 feet (3.7 m) of medium to coarse sand with fine gravel (Table 4). A sample of the material from the test hole also contained 30 percent gravel, 69 percent sand and 1 percent fines (Figure 10a). Data from the Ministry of Transportation indicate that the material from the pit is suitable for use in granular base course and H.L. no. 4 stone if selective extraction and sand control measures are employed in certain sections of the pit. Blending is required to produce sand products.

In Laird Township, an ice-contact stratified drift deposit and a glaciolacustrine beach deposit near Neebish have been selected for secondary protection. Pit no. 37 has been opened in the ice-contact deposit. The dominant material in the pit is fine to coarse gravel, with the gravel content ranging between 40 to 50 percent. Although no quality data is available for the deposit, it is likely that pit run granular base course and fill may be the most readily produced aggregate products. With selective extraction and sand control measures, small lenses of coarse gravel within the pit may be used for crushing.

Three pits have been established in the beach deposit located north of Neebish. Face heights in the pits ranged between 5 to 10 feet (1.5 to 3 m) and exposed openwork fine gravel, and well imbricated fine gravel interstratified with medium to coarse sand. A sample containing 28 percent gravel, 71 percent sand and 1 percent fines was taken from pit no. 36 (Figure 5a). Ministry of Transportation data for pit no. 36 indicate that the sandy aggregate in the deposit appears to be suitable for uses including G.B.C. C and fill. Blending would be required to produce hot-laid sand products. The depth of extraction may be restricted in places by a high water table, as indicated by the presence of water on the floors of pit nos. 34 and 35. The remaining resources in this deposit appear to be well suited for local pit run uses.

An extensive ice-contact deposit located south of MacLennan in central Tarbutt Additional geographic township, has been selected at the secondary level of significance. This deposit flanks Resource Area 2. Four pits have been opened in the deposit (pit nos. 48, 50, 55 and 56). Face heights in the pits ranged from 5 to 40 feet (1.5 to 12 m), and gravel contents ranged from less than 10 percent to 40 percent. Many of the pits were overgrown and/or depleted, and sand was the dominant material present. Pit no. 56 exhibited a 15- to 40-foot (5 to 12 m) face of lacustrine sand overlying fine to coarse gravel. Coarse crushable gravel and fine to medium sand were located in lenses below the fine silty lacustrine sand. Ministry of Transportation files indicate that material from coarse lenses in pit no. 56 has been used in the past to produce G.B.C. A and C, 16 mm Crushed Type A and B stone and Hot-Laid No. 4 stone, with selective extraction and sand control measures. Sand gradations vary from fine to coarse and blending will be required to produce acceptable aggregate products.

Two ice-contact deposits in Johnson Township have been selected for secondary resource protection. Pit no. 73 has been developed in the deposit located south of Portlock, below King's Highway 17. The deposit was laid down on the flanks of a rock outcrop and subsequently covered by lacustrine sand and clay.

The 10- to 25-foot (3 to 8 m) face in pit no. 73 revealed lenses of fine to coarse gravel and fine to coarse sand. Most of the crushable gravel is now depleted. Silt and minor amounts of oversize material were noted. Data from the Ministry of Transportation indicate that material from the pit has been processed to produce a wide range of crushed stone products in the past. The fine aggregate in this pit also has potential to be used in asphalt sand products if it is blended to produce a suitable gradation.

A small ice-contact deposit located south of the hamlet of Gordon Lake has also been selected at the secondary level. Pit no. 58, developed in the deposit, exhibited face heights ranging from 5 to 30 feet (1.5 to 9 m). Although pockets of fine gravel occur sporadically, sand with fine gravel is the dominant material exposed. A sample containing 22 percent gravel, 76 percent sand and 2 percent fines was taken from the pit (Figure 6a). The gravel in the pit is generally too fine for crushing, however, the material appears to be well suited for pit run products. Seismic line ST-GT-3 indicates that aggregate may be available from beneath the pit floor.

In Plummer Additional Township six deposits have been selected for resource protection at the secondary level. Two of these deposits are located near Gordon and Round Lakes in western Plummer geographic township. They consist of glaciolacustrine beach deposits that generally contain well imbricated, fine to medium gravel interstratified with coarse sand. Lenses of coarse gravel were observed in pit nos. 75 and 81. The depth of the deposit located east of Gordon Lake is irregular, as the material is draped around a bedrock ridge. Pits in the deposit have faces ranging in height from 8 to 40 feet (2 to 12 m), exposing variable amounts of gravel. A sample containing 23 percent gravel, 75 percent sand and 2 percent fines was taken from pit no. 81 (Figure 7a). The aggregate from both deposits generally appears to be suitable for both crushed stone and pit run products. Ministry of Transportation files indicate that with processing, lenses of coarse material from pit nos. 75 and 85 have been used in the past for G.B.C. A, 16 mm Crushed Type A and B and H.L. No. 4 stone. The sand fraction of the aggregate requires blending for use in asphaltic sand. At the time of field investigation, aggregate from pit nos. 75 and 76 was being used for local pit run uses.

Four ice-contact deposits scattered throughout Plummer Additional Township have also been selected at the secondary level of significance. Eight pits have been opened in the deposits with faces ranging from 8 to 40 feet (2 to 12 m) in height. The material in the pits showed the variability typical of ice-contact deposits, ranging from seams of silt and clay to oversize boulders. The dominant material exposed in the pits is sandy fine gravel which appeared to be well suited for pit run products. Lenses or pockets of poorly sorted coarse gravel, which may be suitable for crushing with the appropriate processing, also occurred. Gravel content was variable. A sample from pit no. 92 contained 32 percent gravel, 66 percent sand and 2 percent fines (Figure 8a). Although pit no. 97 is largely depleted, data from the Ministry of Transportation indicate that with sand control, material obtained from a coarse lens in the pit has been used for a wide range of granular base course and hot-laid stone products. Sand gradations are variable and blending is required to produce hot-laid sand products. Development of these ice-contact deposits is limited for reasons concerning aggregate quality, variability, and thickness, but the deposits have value for local use.

SELECTED SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE, ST. JOSEPH ISLAND (MAP 2B)

In St. Joseph Township, several beach deposits and an esker deposit have been selected at the secondary level of significance. Two portions of the esker south of Richards Landing have been so selected. In one pit in the esker, predominantly coarse gravel is exposed in multiple faces which are 6 to 10 feet (1.8 to 3 m) in height (pit no. 116). Sand is exposed in one face, and in another area clay caps the sand and gravel. Pit no. 115 exposes mostly fine to silty fine sand with minor fine gravel seams. A lens of crushable gravel occurs in the southern part of the pit. Ministry of Transportation data indicate that selective extraction and sand control measures should be employed when processing the crushable gravel. The sand must be blended in order to be used in hot laid asphalt products. The potential for locating crushable material is higher in the gravel portion of the esker.

Four beach deposits have also been chosen as secondary resource areas. A beach deposit located west of Campement d'Ours Island contains pit no. 119. The pit faces are partially overgrown, but the pit appears to contain fine to coarse gravel in a silty, coarse sand matrix. Some oversize clasts were noted. Water was observed on the pit floor and may limit the depth of extraction in the deposit. Ministry of Transportation data indicate that material from this pit has been used to produce crushed aggregate products for road work. Five pits have been developed in two beach deposits located west of Gawas. Face heights range from 3 to 6 feet (1 to 1.8 m), and expose coarse sand to coarse gravel. Some of the aggregate is coated with fines, and water was observed on the floor of two of the pits. The material in these deposits appears to be suitable for pit run products. Ministry of Transportation data indicate that selective extraction and sand control measures should be used during crushing operations in pit no. 123. Blending is required in order to use the sand in hot-laid asphalt products. The presence of soft limestone clasts in the aggregate may limit its use in certain products. A beach deposit northeast of the esker south of Richards Landing may contain aggregate similar to that found in the beaches described above. It is recommended that testing to determine the depth and quality of the material be performed prior to undertaking extraction.

Three beach deposits in Jocelyn Township are considered to be secondary resources. In the deposit located southeast of Richardson Point, two pits have been developed. The faces in pit no. 129 revealed 8 to 10 feet (2 to 3 m) of fine to coarse gravel in a medium sand matrix. Ten to twenty feet (3 to 6 m) of aggregate was exposed in pit no. 128. In the top 10 feet (3 m), gravel bedded with medium sand was observed. Some of the gravel clasts were coated with fines. Below, a higher silt content was noted and the sediments were not as well bedded. The aggregate in this deposit is suitable for pit run uses. Crushed stone may be produced from pit no. 129 if selective extraction is used.

A narrow beach deposit located at the south end of the township contains two pits, one of which was overgrown at the time of investigation. The other pit (no. 143) exposed 4 to 5 feet (1.2 to 1.5 m) of fine to coarse gravel in a medium sand matrix. This material appeared to be suitable for pit run uses.

The largest secondary area on St. Joseph Island is a beach deposit which adjoins Selected Resource Area 10a in both Jocelyn and Hilton Townships. Seven pits have been developed in this secondary resource area. Four to ten feet (1.2 to 3 m) of clean, medium to coarse sand with minor fine to medium gravel clasts were exposed in pit nos. 135 and 137. Seismic line ST-GT-8 indicates the possibility that aggregate extends to a significant depth below the floor of pit no. 137 (Table 5; Map 1B). Pit no. 140 contained predominantly gravel in a medium sand matrix, however a pocket of clean medium sand was noted. Overgrown faces, 3 to 5 feet (1 to 1.5 m) in height were noted in pit nos. 136 and 141. In Hilton Township, pit nos. 150 and 151 contained 3 to 10 feet (1 to 3 m) of fine to coarse gravel in a clean medium sand matrix. The material appeared to be suitable for pit run uses, and may be suitable for crushing if selective extraction and sand control measures are used.

Near Milford Haven in Hilton Township, two beach deposits have been selected at the secondary level of significance. Two pits have been developed in the larger of these deposits. Pit no. 157 contained fine to coarse gravel with minor amount of oversize clasts exposed in 4- to 5-foot (1.2 to 1.5 m) faces. Pit no. 158 had 4- to 6-foot (1.2 to 1.8 m) faces which revealed clean coarse sand and fine openwork gravel interbedded with fine to medium sand. The sand and gravel in this deposit is suitable for fill and pit run uses, and crushing if selective extraction measures are applied. Ministry of Transportation data indicate that the depth of extraction in this deposit may be limited by the presence of till, and by the water table. Similar material may be located in the rest of this deposit, and in the deposit southwest of this one. Testing should be undertaken prior to extraction to determine the depth and nature of the material in these deposits.

SAND AND GRAVEL RESOURCES OF TERTIARY SIGNIFICANCE

The remaining sand and gravel resources within the report area have been classified at the tertiary level of significance. The tertiary deposits generally contain poor quality aggregate and/or limited quantities of aggregate, or are deposits for which quality information is lacking. These deposits include glaciolacustrine beach gravel and plain sand, and undifferentiated ice-contact stratified drift deposits and kames.

The lacustrine sand is often excessively fine and poorly graded, and the use of these deposits is generally limited to low specification uses such as fill (ST-SS-1, Rose geographic township, Map 1A; Figure 10a). Many of the ice-contact deposits on the mainland contain excessive amounts of clay and silt. These deposits were laid down against bedrock and are often patchy and discontinuous, and are difficult to access and investigate with power equipment. On St. Joseph Island, some of the kame deposits have limited areal extent and are overlain by clay. These factors reduce their extractive potential. The tertiary beach deposits are shallow and composed of reworked till. The gravel in these deposits is poorly sorted and clay coated. Despite these drawbacks, the tertiary deposits may have importance when short haul distances are of more importance than the quality of the aggregate.

BEDROCK RESOURCE POTENTIAL

An alternative source of aggregate within the study area is bedrock-derived aggregate. The regional geology of the area is portrayed in Figure 2. For detailed descriptions of the geology and mineral potential of the rocks in the area, the reader is referred to reports and mapping by Liberty (1967), Frarey (1977), Springer (1977), Giblin and Leahy (1979), Bennett (1982), and Russell (1985, 1987). The following discussion is based on the work of these authors.

The bedrock in the Echo Bay-Bruce Mines Area is primarily made up of a complex array of rocks of Middle Precambrian age. These rocks consist predominantly of metasedimentary rocks of the Huronian Supergroup and Nipissing diabase. These units also outcrop along portions of the northern edge of St. Joseph Island. Precambrian rocks often show a wide variation in mineralogy, texture (grain size) and degree of weathering, even within specific rock types and over relatively short distances. Some rock types may react slowly with cement, eventually leading to concrete deterioration. The argillites, greywackes and sandstones of the Huronian Supergroup are alkali-reactive and

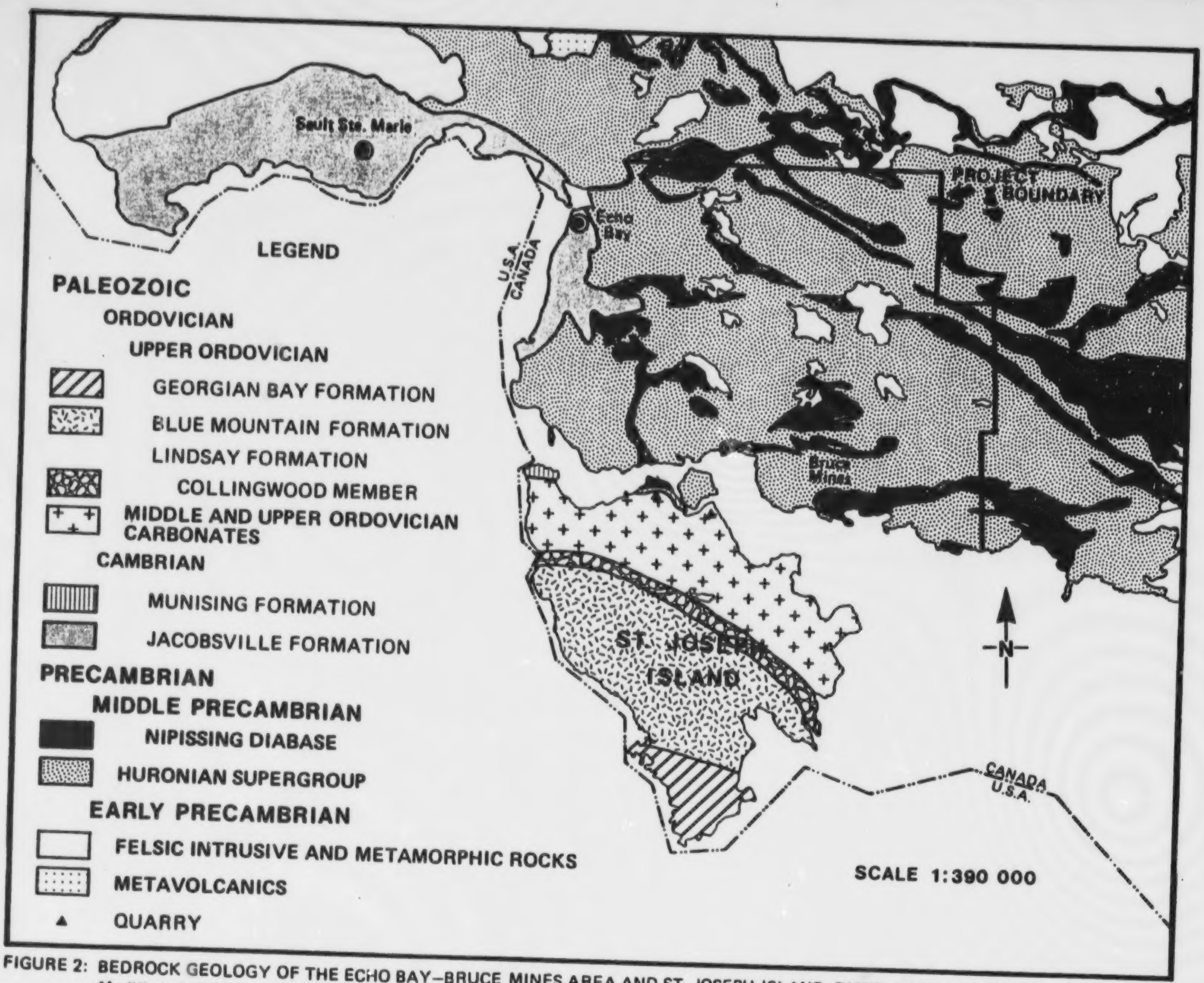
Sault Ste. Marie
Echo Bay
U.S.A.
CANADA
PROJECT BOUNDARY
Bruce Mines
ST. JOSEPH ISLAND
N
CANADA
U.S.A.
SCALE 1:390 000
LEGEND
PALEOZOIC
ORDOVICIAN
UPPER ORDOVICIAN
GEORGIAN BAY FORMATION
BLUE MOUNTAIN FORMATION
LINDSAY FORMATION
COLLINGWOOD MEMBER
MIDDLE AND UPPER ORDOVICIAN CARBONATES
CAMBRIAN
MUNISING FORMATION
JACOBSVILLE FORMATION
PRECAMBRIAN
MIDDLE PRECAMBRIAN
NIPISSING DIABASE
HURONIAN SUPERGROUP
EARLY PRECAMBRIAN
FELSIC INTRUSIVE AND METAMORPHIC ROCKS
METAVOLCANICS
▲ QUARRY

FIGURE 2: BEDROCK GEOLOGY OF THE ECHO BAY–BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA
Modified after Giblin and Leahy (1979) and Russell (1987, 1985)

should be avoided for use in portland cement concrete applications (Rogers 1985). As these factors are important in determining the suitability of rock for use as aggregate, any site should be thoroughly tested prior to extractive development.

Part of the mainland study area and most of St. Joseph Island is underlain by Paleozoic shale and carbonates. Sandstone of the Cambrian age Jacobsville Formation underlies parts of Macdonald geographic township and Laird Township on the mainland. On St. Joseph Island, a narrow band of sandstone of the Cambrian age Munising Formation occurs south of the Precamrian rocks. The remainder of the island is underlain by Middle and Upper Ordovician age rocks including undifferentiated carbonates, the Collingwood Member of the Lindsay Formation, the Blue Mountain Formation and the Georgian Bay Formation. Outcrop of Paleozoic rocks on St. Joseph Island is restricted to the northern rim of the island. Elsewhere, the bedrock is deeply covered by glacial deposits, limiting the potential of the rock units for extractive development.

Of the rock types in the report area, the Nipissing diabase is believed to be best suited for possible bedrock extraction. As well as being a potential source of high specification aggregate, diabase is also suitable for many industrial mineral applications. Factors such as the abrasive nature of the diabase on crushing equipment, the purity of the rock, the joint patterns, and the potential markets would influence quarry development.

Three quarries have been opened in the Nipissing diabase. One quarry is located immediately east of the town of Bruce

Mines, another is near the intersection of King's Highway 17 and Secondary Highway 548, and a third is located on St. Joseph Island off Highway 548, south of the road bridge connecting the island to the mainland. Trap rock was mined from a 10- to 20-foot (3 to 6 m) face in the quarry near Bruce Mines, between the late 1800's and the early 1900's. Trap rock from this quarry was used in construction of the ship locks at Sault Ste. Marie, Michigan, and used in road construction in the City of Cleveland. The quarry on St. Joseph Island also provided trap rock for the building of the locks at Sault Ste. Marie, Michigan (Reinecke 1916). The diabase was mined from a 15- to 20-foot (5 to 6 m) face. Both quarries are now inactive.

Two quarries in the undifferentiated Middle and Upper Ordovician carbonates are found on St. Joseph Island. One quarry is adjacent to Secondary Highway 548, just south of the previously discussed Nipissing diabase quarry. Thinly bedded limestone and shaley limestone is exposed in 6- to 12-foot (1.8 to 3.7 m) faces. The material does not appear to be suitable for general construction purposes. The rock was used as rock fill in the building of the road access bridge to the mainland (Russell 1985). Settlement in the bridge abutments caused by the shale component in the limestone made remedial work necessary (Russell 1985). The second quarry, located south of Canoe Point, revealed 3 to 4 feet (1 to 1.2 m) of thinly bedded carbonates.

If future demand for high specification aggregate increases, bedrock resources may increase in importance. Such demand may be experienced as existing sand and gravel resources near depletion or if large-scale construction projects are undertaken.

SUMMARY

Sand and gravel deposits in the report area are the product of glacial activity which occurred during the Wisconsinan Substage of the Pleistocene Epoch. Fourteen deposits containing significant amounts of sand and gravel have been selected at the primary level of significance. These deposits, grouped into ten Primary Resource Areas and considered to have the greatest potential for extractive development, consist of aggregate ranging from sand to crushable gravel. A number of deposits have also been selected at the secondary level. These areas are able to supply aggregate for local use and add considerably to the resource base for the report area. Except for Tarbutt and Meredith geographic townships where the resource base is limited, the townships in the report area contain sufficient aggregate resources to meet local needs. Care should be taken to ensure the continued availability of as much of the resource areas as possible.

Bedrock is an alternative source of aggregate in the study area. The bedrock consists of a complex array of metasedimentary and intrusive rocks, as well as sandstone, shale and carbonates of Paleozoic age. Nipissing diabase is considered to be the best possible source of rock for crushed stone production.

Enquiries regarding the Aggregate Resources Inventory of the Echo Bay-Bruce Mines Area and St. Joseph Island, District of

Algoma, should be directed to the Aggregate Assessment Office, Engineering and Terrain Geology Section, Ontario Geological Survey, Mines and Minerals Division, Ontario Ministry of Northern Development and Mines, Room M1B-45, Macdonald Block, Queen's Park, Toronto, Ontario M7A 1W4 [Tel. (416) 965-1663], or to the Resident Geologist, Ontario Ministry of Northern Development and Mines, 875 Queen Street East, Sault Ste. Marie, P6A 2B3 [Telephone (705) 949-1231] or to the Sault Ste. Marie District Office, Ontario Ministry of Natural Resources, 875 Queen Street East, Sault Ste. Marie, Ontario, P6A 5L5 [Tel. (705) 949-1231].

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
ECHO BAY-BRUCE MINES AREA			
Macdonald, Meredith and Aberdeen Additional Township			
Macdonald Geographic Township			
1	G-IC	340 (138)	51 (46)
2	G-IC	45 (18)	2 (2)
3	G-IC	55 (22)	1 (1)
4	G-LB	35 (14)	<1 (<1)
		475 (192)	54 (49)
Meredith Geographic Township			
3	G-IC	12 (5)	<1 (<1)
	S-IC	60 (24)	1 (1)
4	S-IC	10 (4)	<1 (<1)
	S-OW	50 (20)	<1 (<1)
		132 (53)	1 (1)

N.B. Minor variations in all tables are caused by rounding of data.

* Identified deposits within the village of Hilton Beach and the St. Joseph Island Bird Sanctuary are omitted on all tables.

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
Aberdeen Additional Geographic Township			
1	G-IC	200 (81)	20 (18)
	S-IC	20 (8)	2 (2)
2	G-IC	310 (125)	12 (11)
	S-IC	50 (20)	2 (2)
3	S-IC	60 (24)	2 (2)
4	G-IC	130 (53)	2 (2)
		770 (310)	40 (36)
Total for Macdonald, Meredith and Aberdeen Additional Township		1380 (560)	95 (86)
Aberdeen Township			
1	G-IC	30 (12)	2 (2)
	S-IC	280 (113)	23 (21)
2	G-IC	155 (63)	6 (5)
	G-LB	5 (2)	<1 (<1)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
	S-IC	65 (26)	2 (2)
	S-LP	25 (10)	<1 (<1)
	S-LP-IC	190 (77)	7 (6)
4	G-IC	240 (97)	3 (3)
	S-IC	270 (109)	3 (3)
	S-LP	365 (148)	5 (4)
		1620 (660)	51 (46)
Laird Township			
2	G-IC	70 (28)	3 (3)
3	G-IC	410 (166)	8 (7)
	G-LB	15 (6)	<1 (<1)
	S-IC	350 (142)	9 (8)
	S-LB	750 (305)	15 (14)
4	G-IC	25 (10)	<1 (<1)
		1620 (660)	35 (32)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
Tarbutt and Tarbutt Additional Township			
Tarbutt Geographic Township			
	- NONE -		
Tarbutt Additional Geographic Township			
1	G-K	140 (57)	7 (6)
2	S-IC	520 (210)	20 (18)
4	S-IC	40 (16)	<1 (<1)
		700 (285)	27 (24)
Johnson Township			
1	S-IC	25 (10)	2 (2)
2	G-IC	250 (101)	9 (8)
	S-IC	290 (117)	11 (10)
3	S-IC	50 (20)	1 (1)
4	G-IC	80 (32)	1 (1)
	S-IC	10 (4)	<1 (<1)
	S-LP	40 (16)	<1 (<1)
		740 (300)	24 (22)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
Plummer Additional Township			
Plummer Geographic Township			
1	G-IC	20 (8)	1 (1)
	S-IC	50 (20)	4 (4)
	S-LB	260 (105)	13 (12)
2	G-IC	345 (140)	13 (12)
	G-LB	5 (2)	<1 (<1)
	S-IC	455 (184)	14 (13)
	S-LP	520 (210)	16 (14)
3	S-IC	90 (36)	2 (2)
	S-LB	230 (93)	5 (4)
	S-LP	490 (198)	10 (9)
4	G-IC	70 (28)	<1 (<1)
	S-IC	5 (2)	<1 (<1)
	S-LB	90 (36)	1 (1)
	S-LP	30 (12)	<1 (<1)
		2650 (1070)	79 (72)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
Rose Geographic Township			
2	G-IC	50 (20)	2 (2)
	S-LP	1130 (455)	40 (36)
3	S-LP	650 (265)	13 (12)
4	G-IC	40 (16)	<1 (<1)
	S-IC	60 (24)	<1 (<1)
	S-LP	470 (190)	6 (5)
		2400 (970)	61 (55)
Plummer Additional Geographic Township			
1	S-IC	180 (73)	9 (8)
3	S-IC	165 (67)	3 (3)
4	S-IC	100 (40)	1 (1)
	S-LP	60 (24)	<1 (<1)
		500 (202)	13 (12)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
Lefroy Geographic Township			
1	S-IC	25 (10)	1 (1)
2	G-IC	100 (40)	3 (3)
3	S-LP	30 (12)	<1 (<1)
4	S-LP	180 (73)	2 (2)
		335 (136)	6 (5)
Total for Plummer Additional Township		5900 (2390)	159 (144)
TOTAL FOR ECHO BAY-BRUCE MINES AREA		12,000 (4850)	390 (355)
ST. JOSEPH ISLAND			
St. Joseph Township			
1	G-LB	28 (11)	2 (2)
2	G-E	40 (16)	1 (1)
	G-K	57 (23)	2 (2)
	G-LB	167 (68)	6 (5)
	S-LP	445 (180)	17 (15)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
	S-LP-WD	1290 (520)	48 (44)
3	G-K	58 (23)	1 (1)
	G-LB	2390 (970)	46 (42)
	S-E	47 (19)	<1 (<1)
	S-LP	3500 (1420)	72 (65)
		8000 (3250)	193 (175)
Jocelyn Township			
1	G-LB	3650 (1480)	275 (250)
2	G-LB	4700 (1900)	141 (128)
	S-LP	1790 (720)	67 (61)
	S-LP-WD	340 (138)	13 (12)
3	G-LB	940 (380)	18 (16)
	S-LP	6300 (2550)	126 (114)
	S-LP-WD	126 (51)	2 (2)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix D)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
4	G-LB	200 (81)	2 (2)
	S-LP	6000 (2430)	60 (54)
		24,000 (9700)	700 (640)
Hilton Township			
1	G-LB	1130 (455)	85 (77)
2	G-K	12 (5)	<1 (<1)
	G-LB	9400 (3800)	325 (295)
	S-LP-WD	400 (162)	15 (14)
3	G-LB	2160 (870)	43 (39)
	S-LP	5300 (2190)	106 (86)
	S-LP-WD	64 (26)	1 (1)
		18,500 (7500)	574 (521)
TOTAL FOR ST. JOSEPH ISLAND:		50,000 (20 200)	1470 (1330)
TOTAL FOR STUDY AREA:		62,000 (25 000)	1860 (1690)

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
ECHO BAY-BRUCE MINES AREA						
Macdonald, Meredith and Aberdeen Additional Township						
Macdonald Geographic Township						
1	-	NW¼ Sec 9		10-12 (3-4)	variable	till pit
2	L31-5	NE¼ Sec 16		50-80 (15-24)	30-60 variable	multiple faces; silty sections
3	-	SW¼ Sec 1		8-10 (2-3)	30-40	
4	L31-18	NW¼ Sec 34		4-6 (1-2)	variable	partially overgrown till pit; bedrock exposed in pit floor
Meredith Geographic Township						
5	-	SE¼ Sec 21		5-6 (1.5-2)	30	gravel occurs in lenses; partially overgrown
6	-	NW¼ Sec 33		3-5 (1-1.5)	20 variable	overgrown pit
Aberdeen Additional Geographic Township						
7	-	5	5	8-10 (2-3)	30-60 variable	partially overgrown
8	-	6	2	10-12 (3-4)	30-50 variable	
9	B22-30	4	2	15-40 (5-12)	20 variable	gravel occurs in lenses; partially overgrown
10	-	5	2	10-15 (3-5)	30-40	partially overgrown
11	-	4	2	5-10 (1.5-3)	variable	partially overgrown

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
12	B22-11	6	2	25-60 (8-18)	30-60 variable	some clay in western face; oversize present
13	B22-48 B22-49	4,5	1	20-50 (6-15)	30-50 variable	ice-contact material flanking bedrock
Aberdeen Township						
14	B22-62	11	5	15-20 (5-6)	20-30 variable	gravel concentrated in beach lag at surface of pit
15	-	12	4	10-15 (3-5)	10-20 variable	sloughed; partially overgrown; gravel occurrence within lenses
16	-	11	4	12-15 (4-5)	20	sloughed & partially overgrown faces
17	-	11	4	5-6 (1.5-2)	10	sloughed and partially overgrown faces
18	-	9	4	10-15 (3-5)	20	partially overgrown
19	-	11	4	10-15 (3-5)	30-40	sloughed faces; bedrock exposed
20	-	11,12	4	20-25 (6-8)	30-40 variable	partially overgrown faces
21	-	9	2	-	-	graded and overgrown
22	B22-65	8	3	40 (12)	10-20 variable	overlain by 5-foot (1.5m) thick layer of lacustrine sand; bedrock exposed
23	B22-54	7	2	50 (15)	10-20 variable	overlain by 3 to 5-foot (1 to 1.5m) thick layer of lacustrine sand; gravel occurs in lenses in pit

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
24	B22-56	10	1	25-30 (8-9)	30-60	sloughed face; ice-contact material flanking bedrock
25	-	1	6	8-12 (2-4)	20	overlain by 3-foot (1m) thick layer of lacustrine sand; gravel occurs in lenses in pit
26	-	3	6	3-5 (1-1.5)	variable	till pit; partially overgrown
27	-	1	5	3-5 (1-1.5)	sand	
28	-	1	4	10 (3)	10	overlain by lacustrine sand; gravel occurs in lenses in pit; partially overgrown
29	B22-55	5	3	10-30 (3-9)	10-20 variable	overgrown; silt seams present
30	B22-55	5	3	10-30 (3-9)	10-20 variable	partially overgrown; silt seams present
31	B22-55	5	3	10-30 (3-9)	10-20 variable	overgrown
32	-	5	3	15 (5)	10-30 variable	overgrown; cementation present
33	B22-38	2	1	15-20 (5-6)	30-50	reworked ice-contact material flanking bedrock
Laird Township						
34	L31-3	NW¼ Sec J		5-10 (1.5-3)	20	overgrown; water on pit floor

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
35	-	NW¼	Sec J	5-10 (1.5-3)	10-20	overgrown; water on pit floor
36	L31-7	NW¼	Sec M	5-10 (1.5-3)	20-30	
37	-	NW¼	Sec N	5-8 (1.5-2)	40-50	overgrown
38	-	NW¼	Sec 29	5-15 (1.5-5)	-	overgrown: water filled
39	-	NW¼	Sec 21	5-12 (1.5-4)	30-40 variable	overgrown; water in pit floor;ice-contact material flanking bedrock; silt seams present
40	-	NW¼	Sec 21	5-15 (1.5-5)	5	partially overgrown
41	L31-10	NW¼	Sec 21	20 (6)	30-40 variable	overgrown; ice-contact material flanking bedrock; silt and clay seams present
42	-	NW¼	Sec 16	8 (2)	30-50	overgrown; water in pit floor
43	-	NW¼	Sec 16	5-15 (1.5-5)	30-40 variable	ice-contact material flanking bedrock; partially overgrown
44	-	SW¼	Sec 1	5 (5)	30-40 variable	
45	-	SW¼	Sec 1	5-8 (1.5-2)	30-40 variable	overgrown
46	-	NW¼	Sec 12	5-10 (1.5-3)	50	partially overgrown; water in floor of pit; large percentage of deleterious material (sandstone)

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
Tarbutt and Tarbutt Additional Township						
Tarbutt Geographic Township						
47	-	5	1	5-12 (1.5-4)	-	overgrown;clay source
Tarbutt Additional Geographic Township						
48	-	7	6	10-15 (3-5)	30-40 variable	overgrown; overlain by lacustrine sand
49	L31-8 L31-11	6	6	10-40 (3-12)	30-60 variable	multiple faces; overgrown water in floor of pit; ice-contact gravel overlain by thick layer of lacustrine sand
50	-	6	5	5-10 (1.5-3)	variable	
51	-	6	5	5-8 (1.5-2)	30-60 variable	overgrown
52	-	6	5	5-15 (1.5-5)	30-70 variable	recent extraction; clay coating on gravel; oversize
53	-	6	5	25-30 (8-9)	40-60 variable	ice-contact material flanking bedrock; partially overgrown; oversize
54	L31-9	6	5	10-15 (3-5)	40-60 variable	multiple faces; partially overgrown
55	L31-16	5	5	5-8 (1.5-2)	10 variable	partially overgrown; overlain by lacustrine sand
56	L31-1	5	5	15-40 (5-12)	20 variable	gravel occurs in lenses; partially overgrown; depleted; water on pit floor

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
Johnson Township						
57	-	5	6	5-8 (1.5-2)	10-20	overgrown; water on pit floor
58	-	3	5	5-30 (1.5-9)	20	partially overgrown; overlain by 2-foot(1m) thick layer of silty sand; gravel occurs in lenses
59	-	3,4	5	5-15 (1.5-5)	10	overgrown
60	-	12	4	5-10 (1.5-3)	variable	till pit
61	-	12	3	8-10 (2-3)	variable	till pit
62	-	24	7	5-6 (1.5-2)	variable	clay pit; overgrown
63	-	1	3	5-10 (1.5-3)	variable	partially overgrown
64	-	1	2	5 (1.5)	30-40	
65	-	5	3	8 (2)	10	partially overgrown
66	-	5	2	10-15 (3-5)	20	partially overgrown; excessive silt present
67	B22-2	5	2	30-40 (9-12)	30 variable	reworked ice-contact material flanking bedrock; partially overgrown; water on pit floor; excessive silt and clay present
68	B22-52	5	7	10-20 (3-6)	40-50 variable	ice-contact material flanking bedrock

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
69	-	4	7	5 (1.5)	30-50 variable	
70	-	2,3	7	10-12 (3-4)	variable	clay pit; overgrown
71	-	2,3	7	10-12 (3-4)	variable	clay pit; overgrown
72	-	M	4	10-20 (3-6)	40-50 variable	recent extraction; overlain by lacustrine sand; bedrock exposed in floor
73	B22-3 B22-29	8	4	10-25 (3-8)	30-40 variable	partially overgrown; overlain by lacustrine sand; bedrock exposed in floor & in pitface; gravel occurs in pockets

Plummer Additional Township

Plummer Geographic Township

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
74	B22-58	9	5	10-12 (3-4)	30-40	partially overgrown
75	B22-60	10	5	8-12 (2-4)	30-40 variable	beach deposit flanking bedrock; recent extraction
76	B22-59	10	5	30-40 (9-12)	20 variable	partially overgrown; recent extraction
77	-	10	5	10-15 (3-5)	10	partially overgrown
78	-	10	5	10-12 (3-4)	sand	excessive silt present; recent extraction

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
79	-	12	4	5 (1.5)	variable	overgrown
80	-	11	3	5-10 (1.5-3)	variable	partially overgrown
81	B22-50	12	3	5-20 (1.5-6)	20-40	worked in two levels
82	-	12	3	5 (1.5)	30-40 variable	partially overgrown
83	-	12	3	5 (1.5)	10	overgrown
84	-	11	3	5-8 (1.5-2)	variable	overgrown; water in pit floor
85	B22-25	11	3	10-30 (3-9)	30-40 variable	sloughed face; partially overgrown
86	B22-67	3	6	5-20 (1.5-6)	30-40	beach deposit flanking bedrock; partially overgrown; sloughed faces
87	-	2	6	10-15 (3-5)	variable	overgrown
88	-	4	6	5-10 (1.5-3)	sand source	
89	-	2	5	8-12 (2-4)	sand source	
90	B22-31	2	6	5-35 (1.5-11)	30-50 variable	sloughed face; gravel occurs in lenses; ice-contact material flanking bedrock
91	-	6	4	10-15 (3-5)	20	recent extraction

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
92	-	7	4	10-12 (3-4)	30-40	recent extraction
93	-	6	4	8-10 (2-3)	30-40	overgrown
94	-	7	4	10 (3)	20 variable	ice-contact material flanking bedrock
95	B22-64	5	4	15 (5)	30-50 variable	recent extraction
96	-	4	3	3-5 (1-1.5)	10-30 variable	
97	B22-24	3	2	30-40 (9-12)	variable	largely depleted; gravel occurs in lenses; partially overgrown
98		4	1	15-20 (5-6)	10-40 variable	gravel occurs in lenses below clayey sand; ice-contact material flanking bedrock
Rose Geographic Township						
99		SW¼ Sec 28		5 (1.5)	10	overgrown
100	B22-66	NW¼ Sec 32		10-15 (3-5)	30-50 variable	sloughed
Plummer Additional Geographic Township						
101	-	6	7	5 (1.5)	variable	ice-contact material flanking bedrock; partially overgrown

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
102	-	5	7	5 (1.5)	variable	overgrown; depleted; bedrock exposed in pit
103	B22-14	5	7	8-10 (2-3)	10	overgrown; water in pit floor; rehabilitated faces
104	-	4	7	8 (2)	10	partially overgrown
105	-	4	5	5-10 (1.5-3)	20	sloughed faces; partially overgrown
106	B22-22	1	5	10-25 (3-8)	20	gravel occurs in lenses; partially overgrown
107	B22-21	1	5	10-20 (3-6)	20	gravel occurs in lenses
Lefroy Geographic Township						
108	-	NW¼ Sec 7		15-20 (5-6)	30-50 variable	reworked ice-contact deposit; partially overgrown
109	-	SW¼ Sec 5		10 (3)	40-50 variable	partially overgrown
ST. JOSEPH ISLAND						
St. Joseph Township						
110	-	8	C	5-15 (1.5-5)	gravel	overlain by 1 to 3 feet (0.3-1m) of red clay
111	-	8	C	-	-	
112	L31-15	6	C	4-10 (1.2-3)	10-30 variable	pit worked in 2 sections; partially overgrown; water on pit floor
113	L31-12	6	D	10-15 (3-5)	40-50	

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
114	-	6	D	8-10 (2-3)	mainly sand	
115	L31-2	9	D	6-10 (1.8-3)	mainly sand	
116	L31-2	9	D	6-10 (1.8-3)	mainly gravel	faces slumped; partially overgrown
117	L31-13	9	E	5-15 (1.5-5)	50-60	overlain by up to 1 foot (0.3m) of clay; faces slumped; partially overgrown
118	L31-13	9	E	10 (3)	30-50	faces slumped; partially overgrown
119		2	5	6-8 (1.8-2)	40-50	partially overgrown; water on pit of floor
120		7	Campement d'Ours Island	6-10 (1.8-3)	30-40	water on pit floor
121	-	6	F	4-5 (1.2-1.5)	mainly sand	worked in several faces
122	-	14	H	4-5 (1.2-1.5)	35-45	
123	B22-39	20	H	3-6 (1-1.8)	10-20	water on pit floor
124	-	19	H	3-5 (1-1.5)	mainly gravel	slumped; overgrown
125	-	21	H	3-4 (1-1.2)	30-40	slumped; overgrown; water on pit floor
126	-	20	I	3-5 (1-1.5)	-	slumped; overgrown
127	-	10	K	8-10 (2-3)	mainly sand	

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
Jocelyn Township						
128	-	32	Neebish	10-20 (3-6)	30-40	some gravel clasts coated with fines
129	-	33	Neebish	8-10 (2-3)	30-40	
130	-	7	M	6-8 (1.2-1.8)	30-40	
131	S32-4	8	M	10-25 (3-8)	40-50	worked in several faces
132	-	11	L	15-20 (5-6)	30-40	faces slumped; partially overgrown
133	-	12	L	5-12 (1.5-4)	40-50	oversize material present
134	-	13	M	5-10 (1.5-3)	30-40 variable	
135	-	36	Neebish	4-6 (1.2-1.8)	mainly sand	
136	-	36	A	4-5 (1.2-1.5)	mainly sand	overgrown
137	-	2	N	4-10 (1.2-3)	mainly sand	
138	S32-4	3	O	10-20 (3-6)	40-60	oversize material present
139	S32-6	5	O	4-10 (1.2-3)	40-50	water on pit floor
140	-	3	T	4-5 (1.2-1.5)	30-40	pocket of sand
141	-	4	T	3-4 (1-1.2)	-	overgrown
142	-	3	3	4-5 (1.2-1.5)	30-40	overgrown
143	-	3	3	4-5 (1.2-1.5)	30-40	recent extraction

TABLE 2 - SAND AND GRAVEL PITS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
144	-	2	4	10-12 (3-4)	10-15	
145	-	5	4	3-4 (1-1.2)	mainly sand	abundant boulders
146	-	A	7	3-4 (1-1.2)	gravel	
Hilton Township						
147	S32-5	1	16	10-12 (3-4)	40-50	faces slumped; partially overgrown
148	S32-3	1	16	10-20 (3-6)	30-40 variable	water on pit floor
149	-	4	15	-	-	presently a garbage disposal site
150	-	20	O	3-6 (1-1.8)	30-40	
151	-	20	P	8-10 (2-3)	30-40	faces slumped; partially overgrown
152	-	7	W	4-5 (1.2-1.5)	gravel	clasts coated with fines; faces slumped; overgrown
153	-	13	14	6-7 (1.8-1.9)	30-50	water on pit floor
154	-	13	W	4-10 (1.2-3)	30-50	gravel clasts are coated with fines; faces slumped; overgrown
155	S32-10	19	13	4-10 (1.2-3)	10	faces slumped; partially overgrown
156	S32-8	24	T	6-30 (1.8-9)	30-50 variable	
157	-	5	10	4-5 (1.2-1.5)	30-50	faces slumped
158	S32-9	6	10	4-6 (1.2-1.8)	5-10	faces slumped

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 Deposit No.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
ECHO BAY-BRUCE MINES AREA						
Macdonald, Meredith and Aberdeen Additional Township						
Macdonald Geographic Township						
1a	340 (138)	65 (26)	15 (6)	260 (105)	60 (18)	39 (35)
1b	45 (18)	0 (0)	0 (0)	45 (18)	20 (6)	2 (2)
	385 (156)	65 (26)	15 (6)	305 (123)		41 (37)
Aberdeen Additional Geographic Township						
3a	200 (81)	60 (24)	15 (6)	125 (51)	40 (12)	12 (11)
3b	300 (121)	80 (32)	10 (4)	210 (85)	15 (5)	8 (7)
	500 (202)	140 (57)	25 (10)	335 (136)		20 (18)
Total for Macdonald, Meredith and Aberdeen Additional Township	880 (355)	205 (83)	40 (16)	640 (260)		61 (55)
Aberdeen Township						
5	30 (12)	5 (2)	5 (2)	20 (8)	25 (8)	1 (1)
6	140 (57)	10 (4)	5 (2)	125 (51)	15 (5)	5 (4)
	170 (69)	15 (6)	10 (4)	145 (59)		6 (5)

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 Deposit No.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
Tarbutt and Tarbutt Additional Township						
Tarbutt Additional Geographic Township						
2	140 (57)	10 (4)	50 (20)	80 (32)	20 (6)	4 (4)
Johnson Township						
4a	95 (38)	17 (7)	8 (3)	70 (28)	15 (5)	3 (3)
4b	70 (28)	5 (2)	5 (2)	60 (24)	15 (5)	2 (2)
	165 (67)	22 (9)	13 (5)	130 (53)		5 (4)
Plummer Additional Township						
Plummer Geographic Township						
5	5 (2)	0 (0)	0 (0)	5 (2)	25 (8)	<1 (<1)
6	60 (24)	5 (2)	5 (2)	50 (20)	15 (5)	2 (2)
7	280 (113)	60 (24)	10 (4)	210 (85)	15 (5)	8 (7)
	345 (140)	65 (26)	15 (6)	265 (107)		10 (9)
Rose Geographic Township						
6	30 (12)	0 (0)	0 (0)	30 (12)	15 (5)	1 (1)

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 Deposit No.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
Lefroy Geographic Township						
8	80 (32)	20 (8)	5 (2)	55 (22)	15 (5)	2 (2)
Total for Plummer Additional Township	455 (184)	85 (34)	20 (8)	350 (142)		13 (12)
TOTAL FOR THE ECHO BAY-BRUCE MINES AREA	1810 (730)	335 (136)	133 (54)	1340 (540)		89 (81)
ST. JOSEPH ISLAND						
St. Joseph Township						
9	57 (23)	0 (0)	3 (1)	54 (22)	12 (4)	2 (2)
10a	28 (11)	0 (0)	0 (0)	28 (11)	30 (9)	2 (2)
10b	167 (68)	35 (14)	0 (0)	132 (53)	15 (5)	5 (4)
	195 (79)	35 (14)	0 (0)	160 (65)		7 (6)
	250 (101)	35 (14)	3 (1)	214 (87)		9 (8)
Jocelyn Township						
10a	3650 (1480)	188 (76)	24 (10)	3450 (1400)	30 (9)	260 (236)

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

1 Deposit No.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
Hilton Township						
10a	1130 (460)	15 (6)	0 (0)	1120 (455)	30 (9)	84 (76)
10b	6500 (2650)	215 (87)	20 (8)	6300 (2550)	15 (5)	236 (214)
	7600 (3100)	230 (93)	20 (8)	7400 (3000)		320 (290)
TOTAL FOR ST. JOSEPH ISLAND:	11,500 (4650)	455 (184)	47 (19)	11,100 (4500)		590 (540)
TOTAL FOR STUDY AREA:	13,300 (5400)	790 (320)	180 (73)	12,400 (5000)		680 (620)

TABLE 4 - SUMMARY OF TEST HOLE DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

ECHO BAY-BRUCE MINES AREA

Macdonald, Meredith and Aberdeen Additional Township

Test Hole Number: ST-TH-1

Location: Macdonald Geographic Township, Section 16, SE¼

Elevation: Approximately 750 to 800 feet (229 to 244 m) a.s.l.

Date: October 6, 1986

Depth feet (metres)	**Description**
0-3.5 (0-1.1)	fine to coarse angular **gravel** with coarse sand
3.5-5.5 (1.1-1.7)	angular, openwork fine **gravel**
5.5-6.5 (1.7-2.0)	fine to coarse angular **gravel** with coarse sand
6.5-7.5 (2.0-2.3)	angular, openwork fine **gravel**
7.5-11.0 (2.3-3.4)	fine to coarse angular **gravel** with trace of coarse sand

Test Hole Number: ST-TH-2

Location: Meredith Geographic Township, Section 19, NE¼

Elevation: Approximately 950 feet (290 m) a.s.l.

Date: October 6, 1986

Depth feet (metres)	**Description**
0-8 (0-2.4)	angular, openwork very coarse **gravel** with coarse sand
8-10 (2.4-3.0)	silty fine **sand** with trace of fine gravel

TABLE 4 - SUMMARY OF TEST HOLE DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

Test Hole Number: ST-TH-3

Location: Aberdeen Additional Geographic Township, Lot 4, Conc.3

Elevation: Approximately 850 feet (260 m) a.s.l.

Date: October 6, 1986

Depth feet (metres)	**Description**
0-8 (0-2.4)	medium to coarse **sand** with trace of fine gravel
8-14 (2.4-4.3)	**silt**

Aberdeen Township

Test Hole Number: ST-TH-4

Location: Aberdeen Township, Lot 11, Conc.5

Elevation: Approximately 1000 feet (305 m) a.s.l.

Date: October 6, 1986

Depth feet (metres)	**Description**
0-4 (0-1.2)	well-rounded fine to coarse **gravel** with clean coarse sand
4-5 (1.2-1.5)	**silt**
5-10 (1.5-3.0)	coarse **sand** with trace of fine gravel

TABLE 4 - SUMMARY OF TEST HOLE DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

Test Hole Number: ST-TH-5

Location: Aberdeen Township, Lot 11, Conc.5
(in floor of pit no. 14)

Elevation: Approximately 950 feet (290 m) a.s.l.

Date: October 6, 1986

Depth feet (metres)	**Description**
0-12 (0-3.7)	medium to coarse sand with fine gravel

Test Hole Number: ST-TH-6

Location: Aberdeen Township, Lot 2, Conc.1

Elevation: Approximately 900 feet (275 m) a.s.l.

Date: October 6, 1986

Depth feet (metres)	**Description**
0-3 (0-0.9)	well-rounded, fine to coarse gravel
3-12 (0.9-3.7)	coarse sand with trace of fine gravel

TABLE 4 - SUMMARY OF TEST HOLE DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

Test Hole Number: ST-TH-7

Location: Aberdeen Township, Lot 2, Conc.1

Elevation: Approximately 900 feet (275 m) a.s.l.

Date: October 6, 1986

Depth feet (metres)	**Description**
0-3 (0-0.9)	well-rounded, fine gravel with medium to coarse sand
3-11 (0.9-3.4)	angular, fine to coarse gravel with medium sand

ST. JOSEPH ISLAND

St. Joseph Township

Test Hole Number: ST-TH-8

Location: St. Joseph Township, Lot 11, Conc. V

Elevation: Approximately 600 feet (183 m) a.s.l.

Date: October 7, 1986

Depth feet (metres)	**Description**
0-1.0 (0-0.3)	coarse sand with minor boulders
1.0-5.0 (0.3-1.5)	sandy till with minor boulders and clay lenses

TABLE 4 - SUMMARY OF TEST HOLE DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

Jocelyn Township

Test Hole Number: ST-TH-9

Location: Jocelyn Township, Lot 6, Conc.5

Elevation: Approximately 800 feet (244 m) a.s.l.

Date: October 7, 1986

Depth feet (metres)	**Description**
0-2.0 (0-0.6)	fine **sand** with trace boulders and cobbles
2.0-9.0 (0.6-2.7)	fine to silty fine **sand** ; water at base of hole

Hilton Township

Test Hole Number: ST-TH-10

Location: Hilton Township, Lot 16, Conc. 13

Elevation: Approximately 750 feet (229 m) a.s.l.

Date: October 7, 1986

Depth feet (metres)	**Description**
0-3.0 (0-1.0)	clean coarse **sand,** with minor fine gravel
3.0-4.0 (1.0-1.2)	**clay** ; water at base of hole

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

ECHO BAY-BRUCE MINES AREA

Macdonald, Meredith and Aberdeen Additional Township

Line Number: ST-GT-1

Line Direction: N 45° E

Method: Hammer Seismic

Location: Macdonald Geographic Township, Section 16, NE¼
(in floor of pit no. 2)

Elevation: Approximately 750 feet (229 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1440 ft/sec (440 m/sec)
V_2 = 8000 ft/sec (2440 m/sec)

Layer Thickness: 13 ft (4 m)

Interpretation: Approximately 13 feet (4 m) of dry sand and gravel over compacted clay or bedrock.

Line Number: ST-GT-2

Line Direction: N 20° E

Method: Hammer Seismic

Location: Aberdeen Additional Geographic Township, Lot 5,
Conc. 5 (in floor of pit no. 7)

Elevation: Approximately 1000 feet (305 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1670 ft/sec (510 m/sec)
V_2 = 34,000 ft/sec (10,400 m/sec)

Layer Thickness: 20 ft (6.1 m)

Interpretation: Approximately 20 feet (6.1 m) of dry sand and gravel over bedrock.

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

Johnson Township

Line Number: ST-GT-3

Line Direction: North - South

Method: Hammer Seismic

Location: Johnson Township, Lot 3, Conc.5
(in floor of pit no. 58)

Elevation: Approximately 700 feet (213 m) a.s.l.

Seismic Data:
Number of Layers: 3
Layer Velocities: V_1 = 1430 ft/sec (435 m/sec)
V_2 = 4000 ft/sec (1220 m/sec)
V_3 = 8000 ft/sec (2440 m/sec)

Layer Thickness: D_1 = 8 ft (2.4 m)
D_2 = 24 ft (7.3 m)

Interpretation: Approximately 8 feet (2.4 m) of dry sand and gravel over clay or till to a minimum of 32 feet (9.8 m).

Plummer Additional Township

Line Number: ST-GT-4

Line Direction: North - South

Method: Hammer Seismic

Location: Plummer Geographic Township, Lot 4, Conc.4

Elevation: Approximately 800 feet (244 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1430 ft/sec (435 m/sec)
V_2 = 12,000 ft/sec (3650 m/sec)

Layer Thickness: 11 ft (3.4 m)

Interpretation: Approximately 11 feet (3.4 m) of dry sand and gravel over bedrock.

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

Line Number: ST-GT-5

Line Direction: North - South

Method: Hammer Seismic

Location: Rose Geographic Township, Section 21, NW¼

Elevation: Approximately 750 to 800 feet (229 to 244 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1250 ft/sec (380 m/sec)
V_2 = 5000 ft/sec (1520 m/sec)

Layer Thickness: 14 ft (4.3 m)

Interpretation: Approximately 14 feet (4.3 m) of loose dry sand over till.

Line Number: ST-GT-6

Line Direction: North - South

Method: Hammer Seismic

Location: Rose Geographic Township , Section 33, NE¼

Elevation: Approximately 800 feet (244 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1330 ft/sec (405 m/sec)
V_2 = 4350 ft/sec (1330 m/sec)

Layer Thickness: 8 ft (2.4 m)

Interpretation: Approximately 8 feet (2.4 m) of loose dry sand over clay or till.

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

ST. JOSEPH ISLAND

Township of Jocelyn

Line Number: ST-GT-7

Line Direction: Northwest - Southeast

Method: Hammer Seismic

Location: Jocelyn Township, Lot 12, Conc. M
(in floor of pit no. 131)

Elevation: Approximately 900 feet (274 m) a.s.l.

Seismic Data:
Number of Layers: 1
Layer Velocities: V_1 = 1400 ft/sec (425 m/sec)

Interpretation: Sand and gravel to a minimum depth of 30 feet(9 m).

Line Number: ST-GT-8

Line Direction: North-northwest - South-southeast

Method: Hammer Seismic

Location: Jocelyn Township, Lot 2, Conc. N

Elevation: Approximately 800 feet (244 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1290 ft/sec (395 m/sec)
V_2 = 5200 ft/sec (1580 m/sec)

Layer Thickness: D_1 = 12 ft (3.7 m)

Interpretation: Approximately 12 feet (3.7 m) of dry sand and gravel over wet sand and gravel to a minimum depth of 40 feet (12.2 m).

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, ECHO BAY-BRUCE MINES AREA AND ST. JOSEPH ISLAND, DISTRICT OF ALGOMA

Line Number: ST-GT-9

Line Direction: North-northwest - South-southeast

Method: Hammer Seismic

Location: Jocelyn Township, Lot 3, Conc. O
(in floor of pit no. 137)

Elevation: Approximately 900 feet (274 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1 = 1110 ft/sec (340 m/sec)
V_2 = 2750 ft/sec (840 m/sec)
Layer thickness D_1 = 3 ft (1 m)

Interpretation: Approximately 3 feet (1 m) of gravelly sand over sand and gravel to a minimum depth of 40 feet (12.2 m).

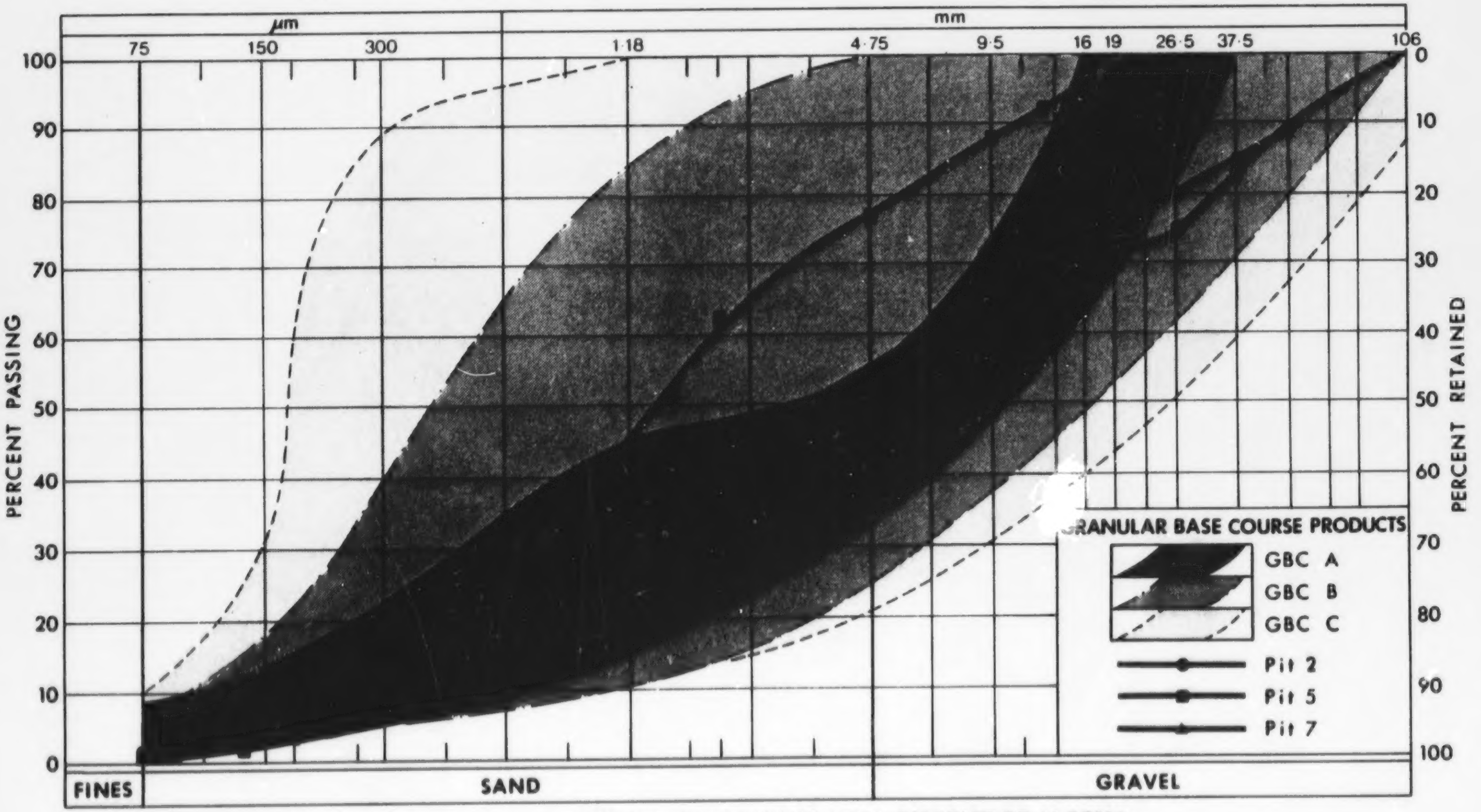

FIGURE:3a AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, **DISTRICT OF ALGOMA;**

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

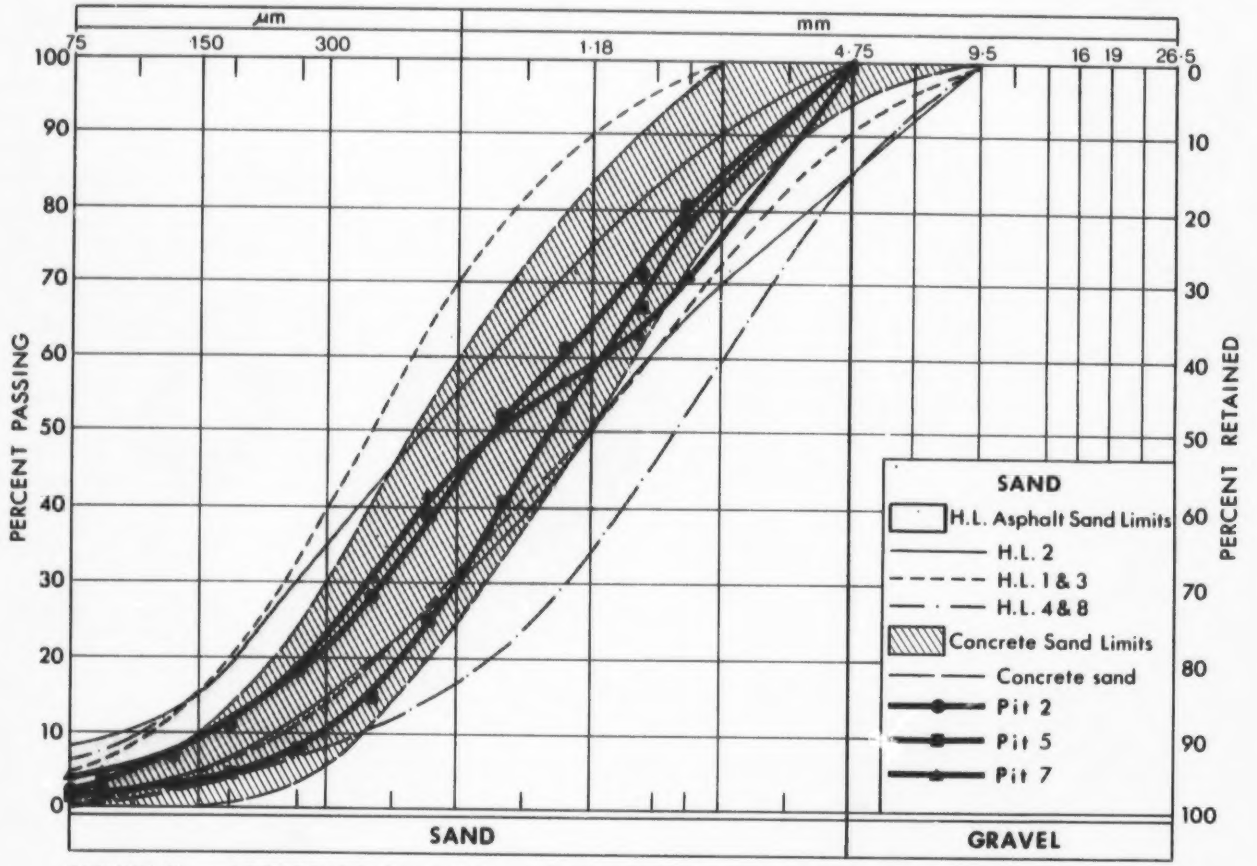

FIGURE:3b AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, **DISTRICT OF ALGOMA;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

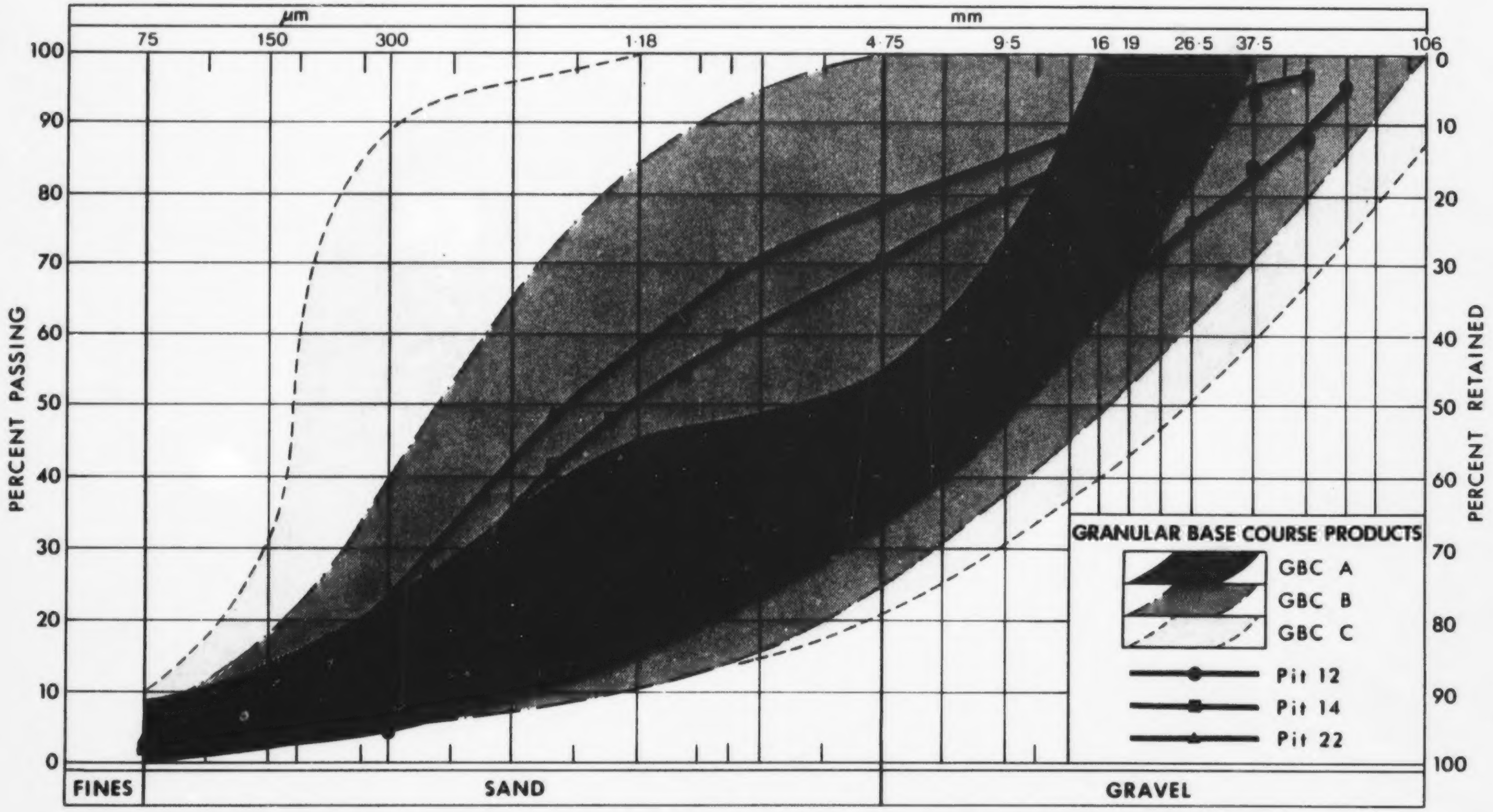

FIGURE:4a AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

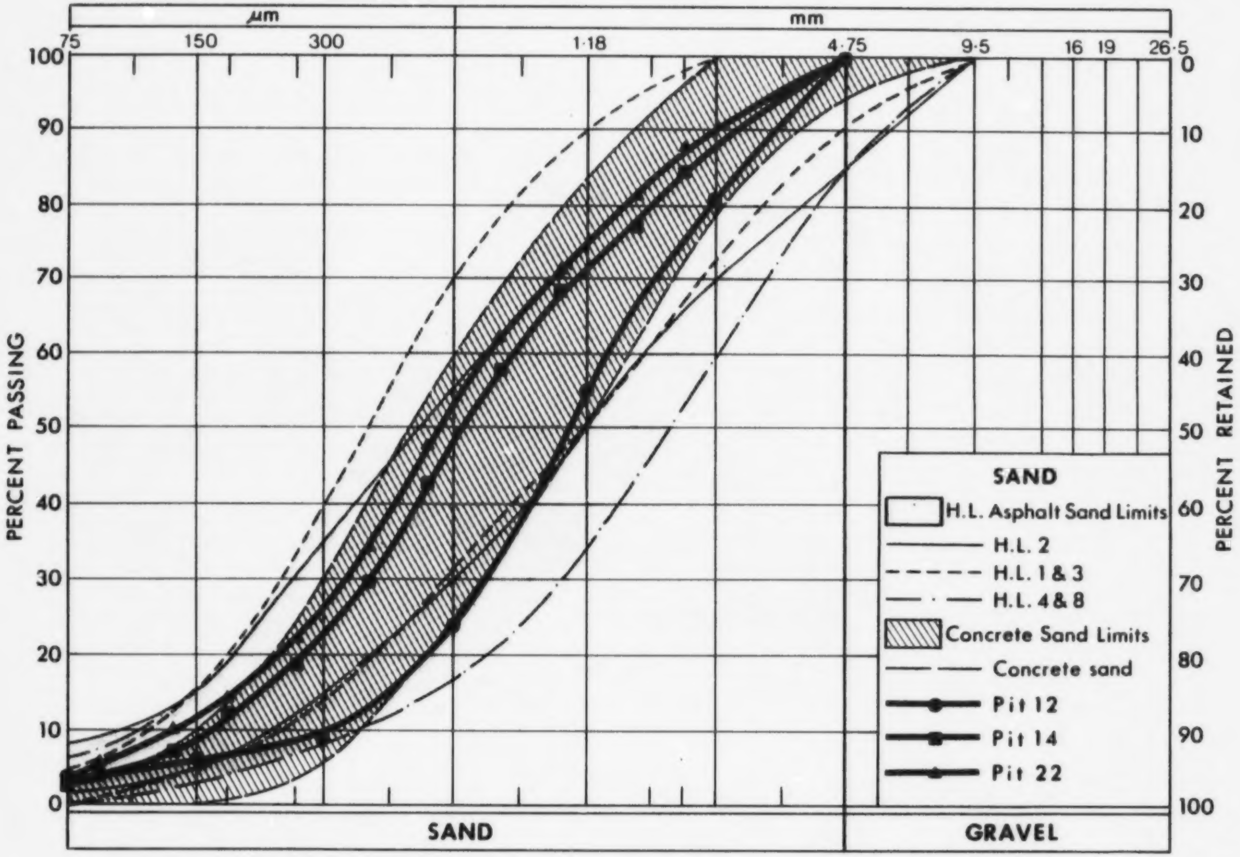

FIGURE:4b AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, **DISTRICT OF ALGOMA;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

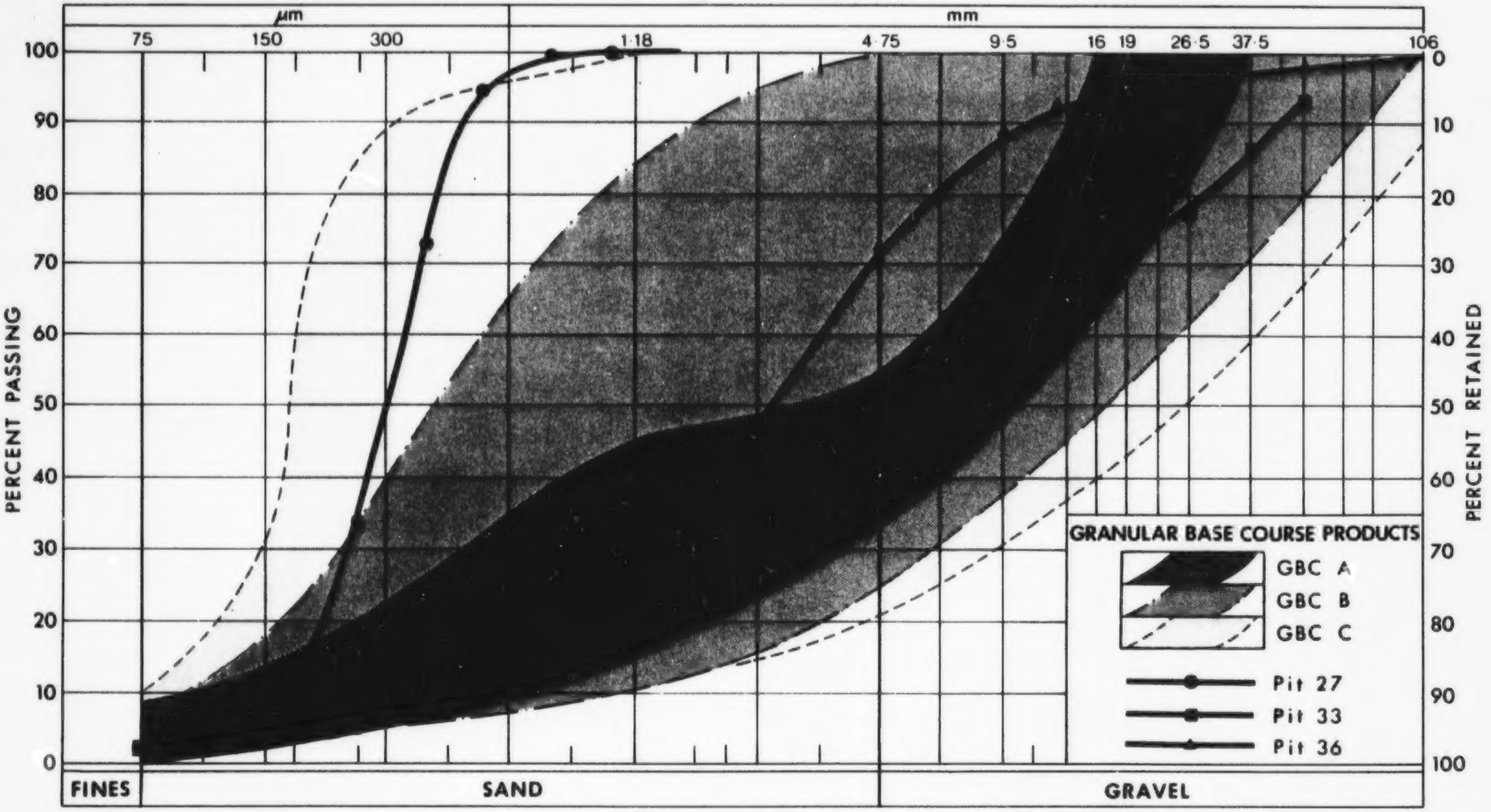

FIGURE :5a AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

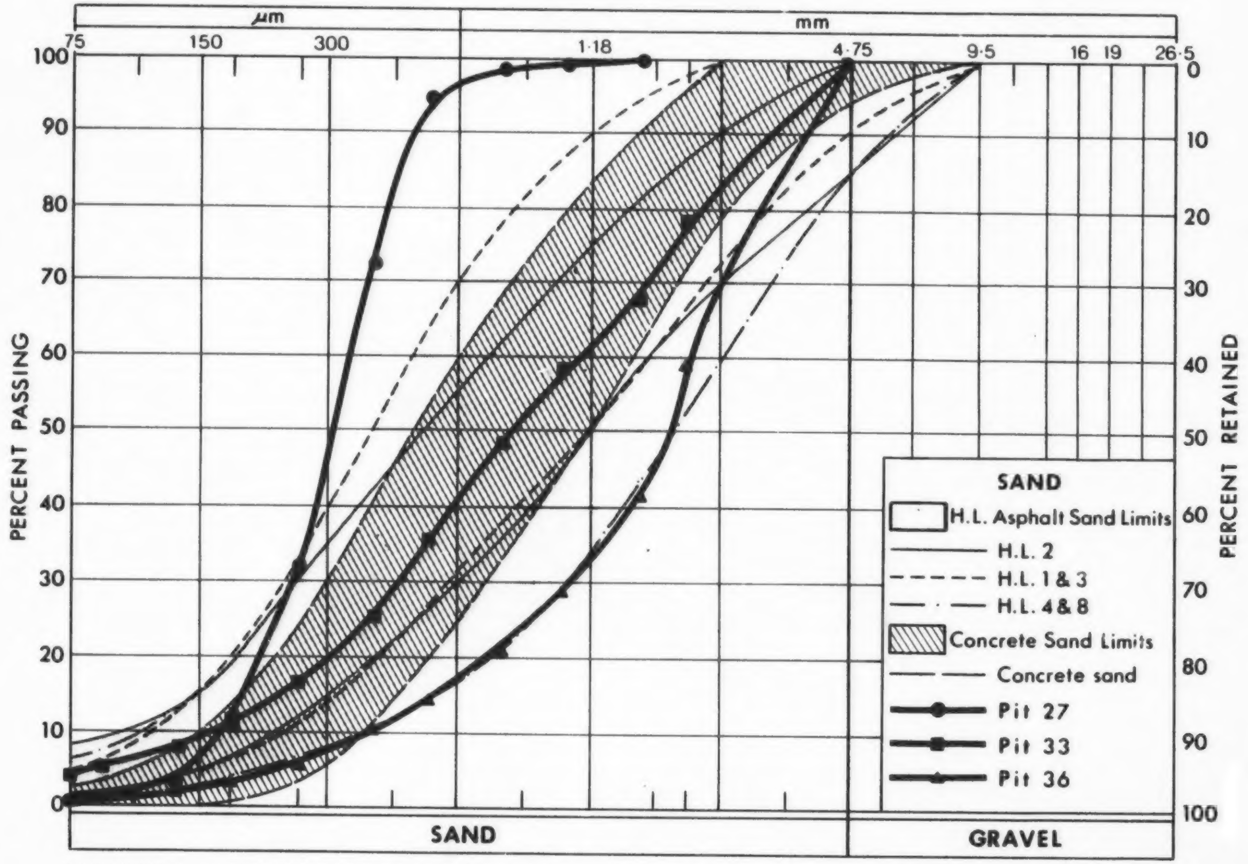

FIGURE :5b AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, **DISTRICT OF ALGOMA;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

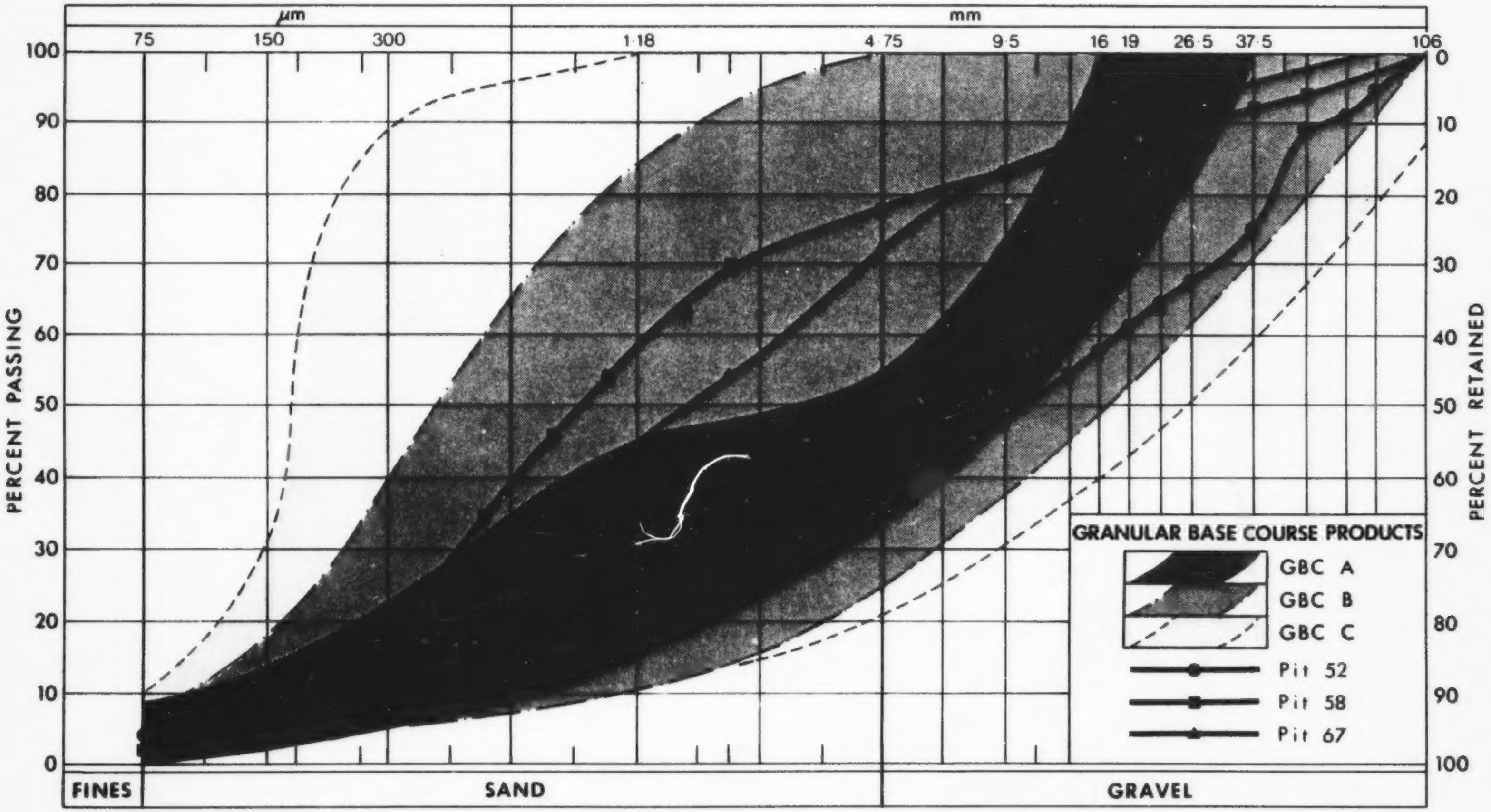

FIGURE :6a AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, **DISTRICT OF ALGOMA;**

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

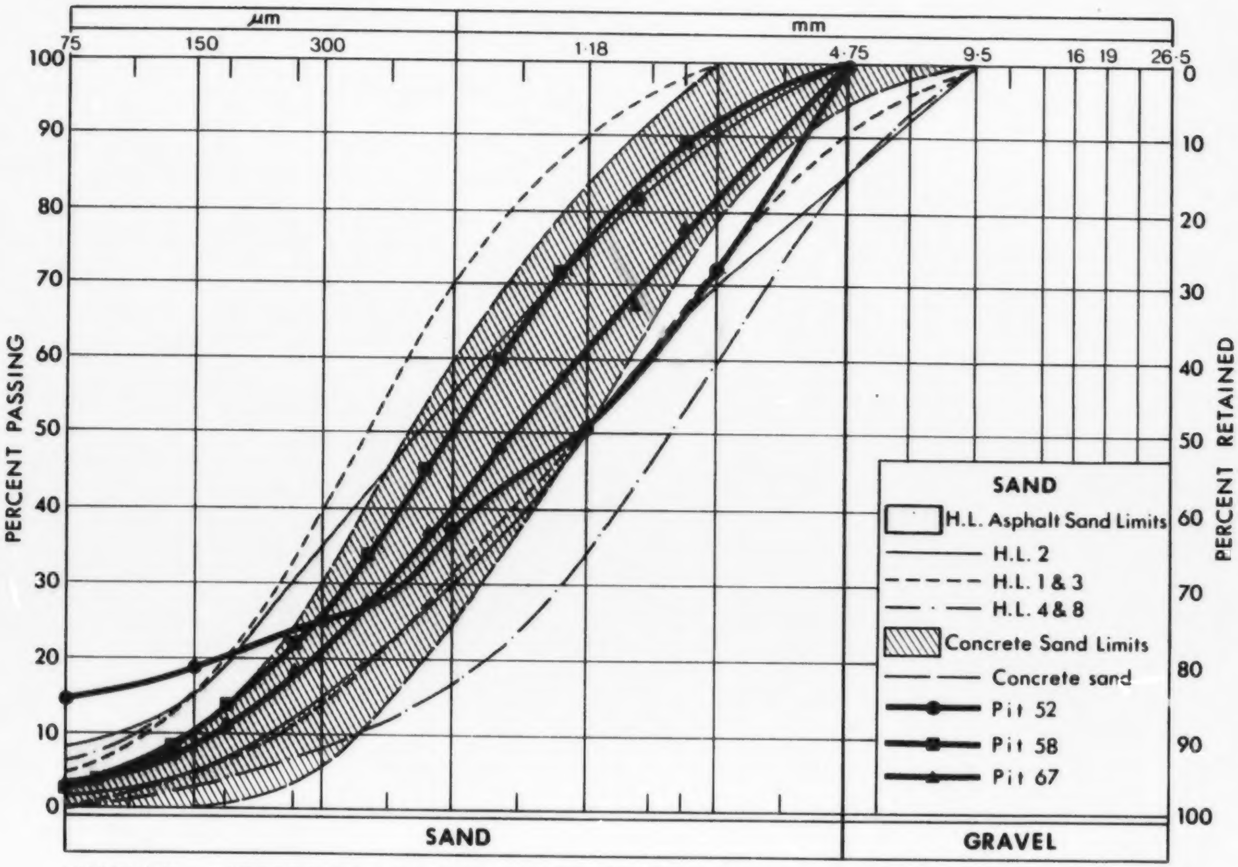

FIGURE: 6b AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, **DISTRICT OF ALGOMA;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

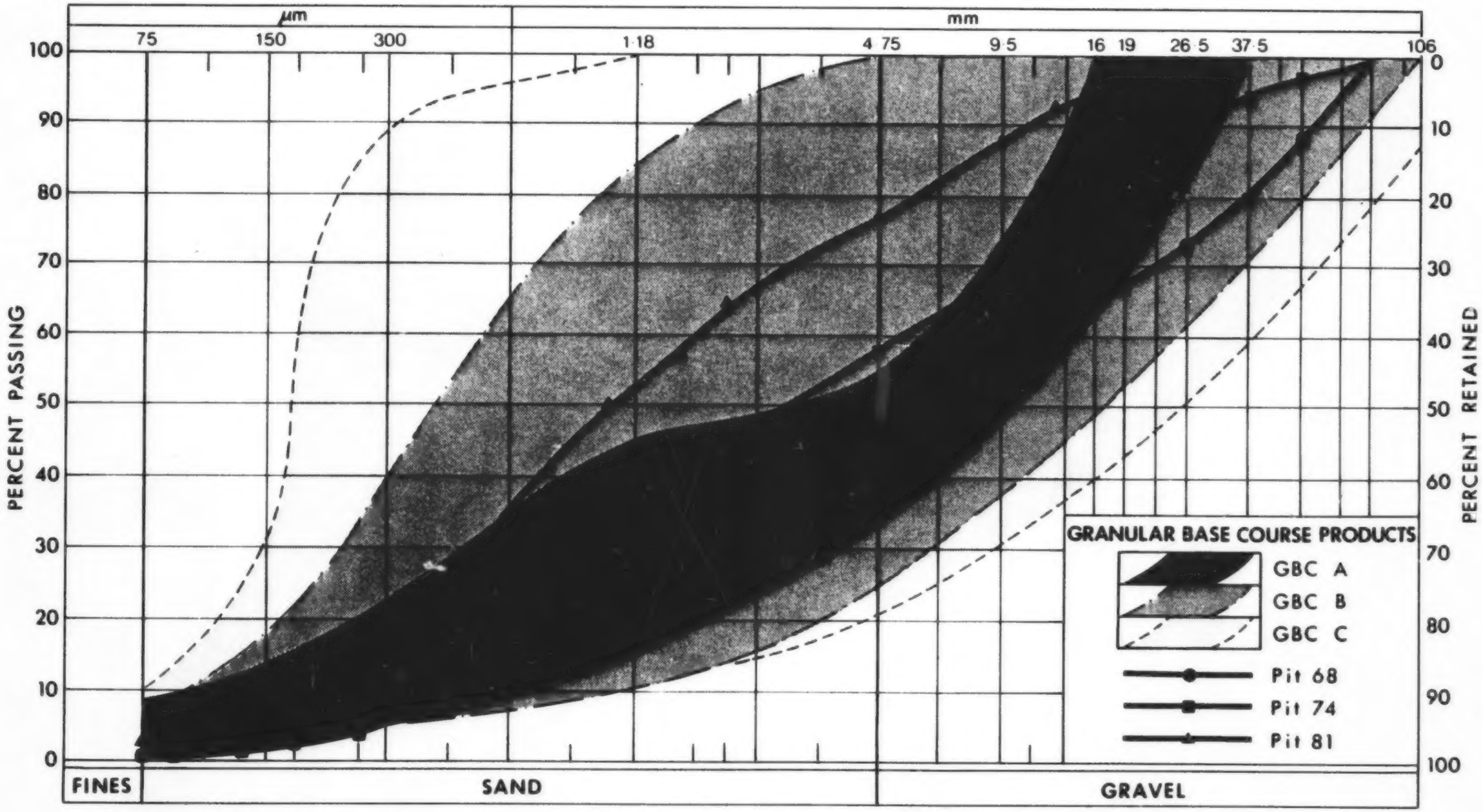

FIGURE : 7a AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

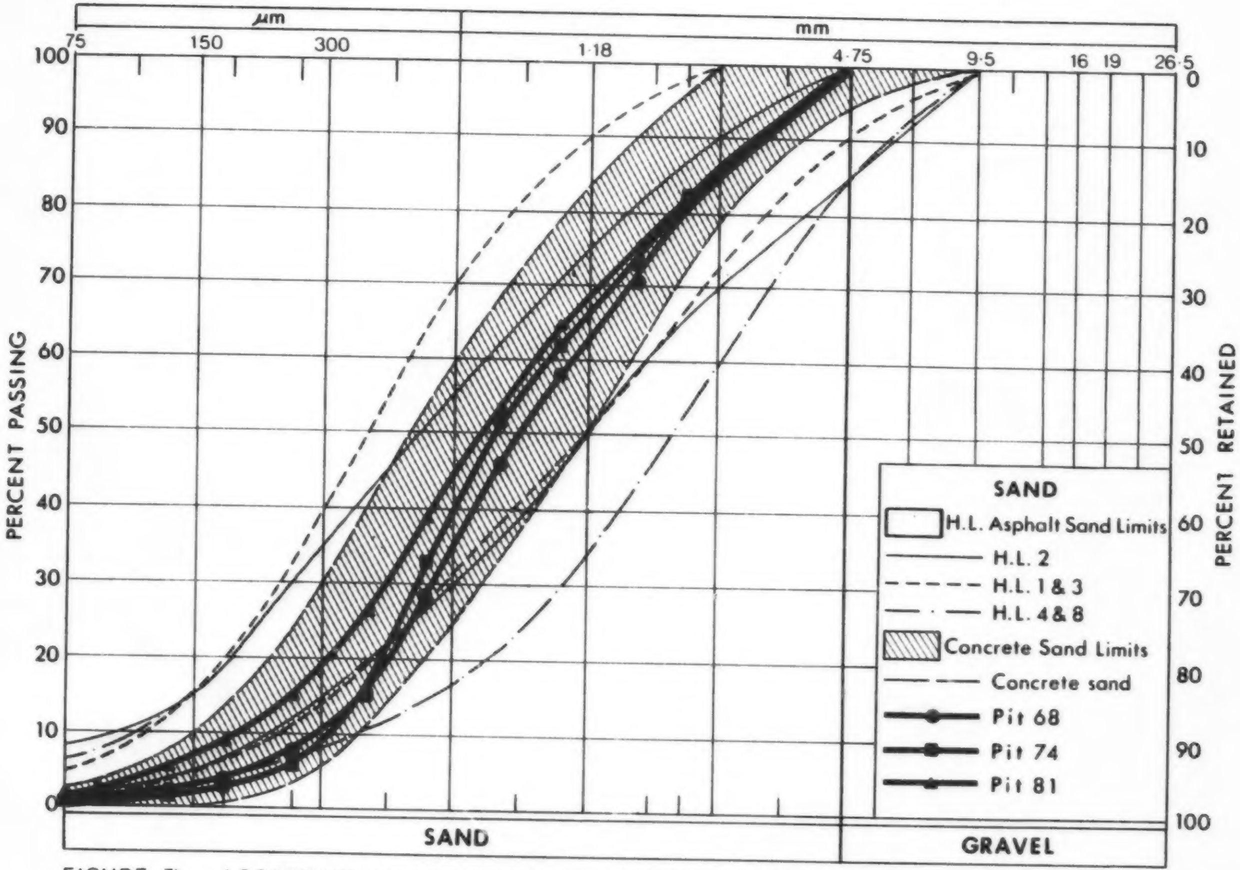

FIGURE : 7b AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, **DISTRICT OF ALGOMA;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

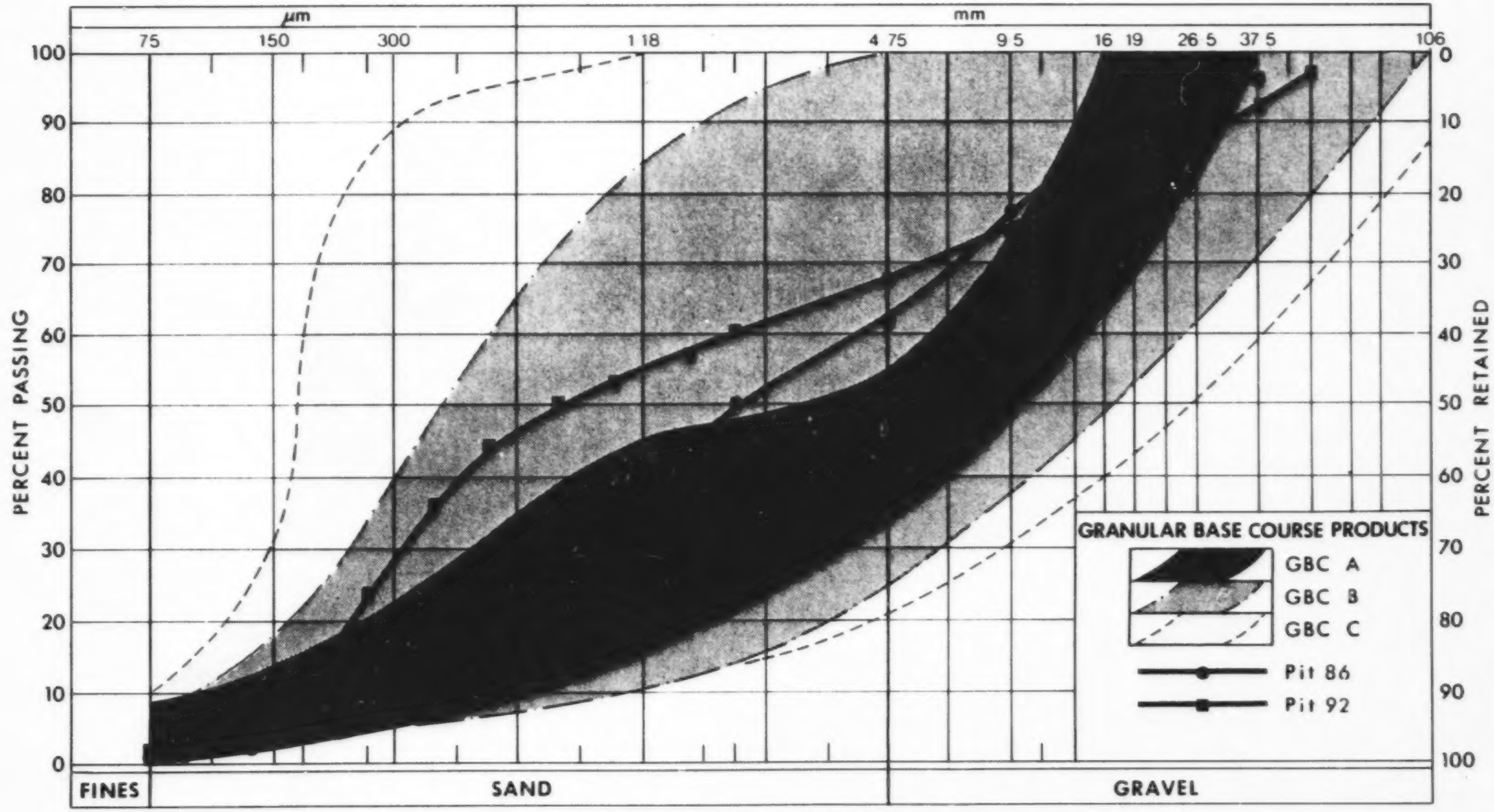

FIGURE :8a AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

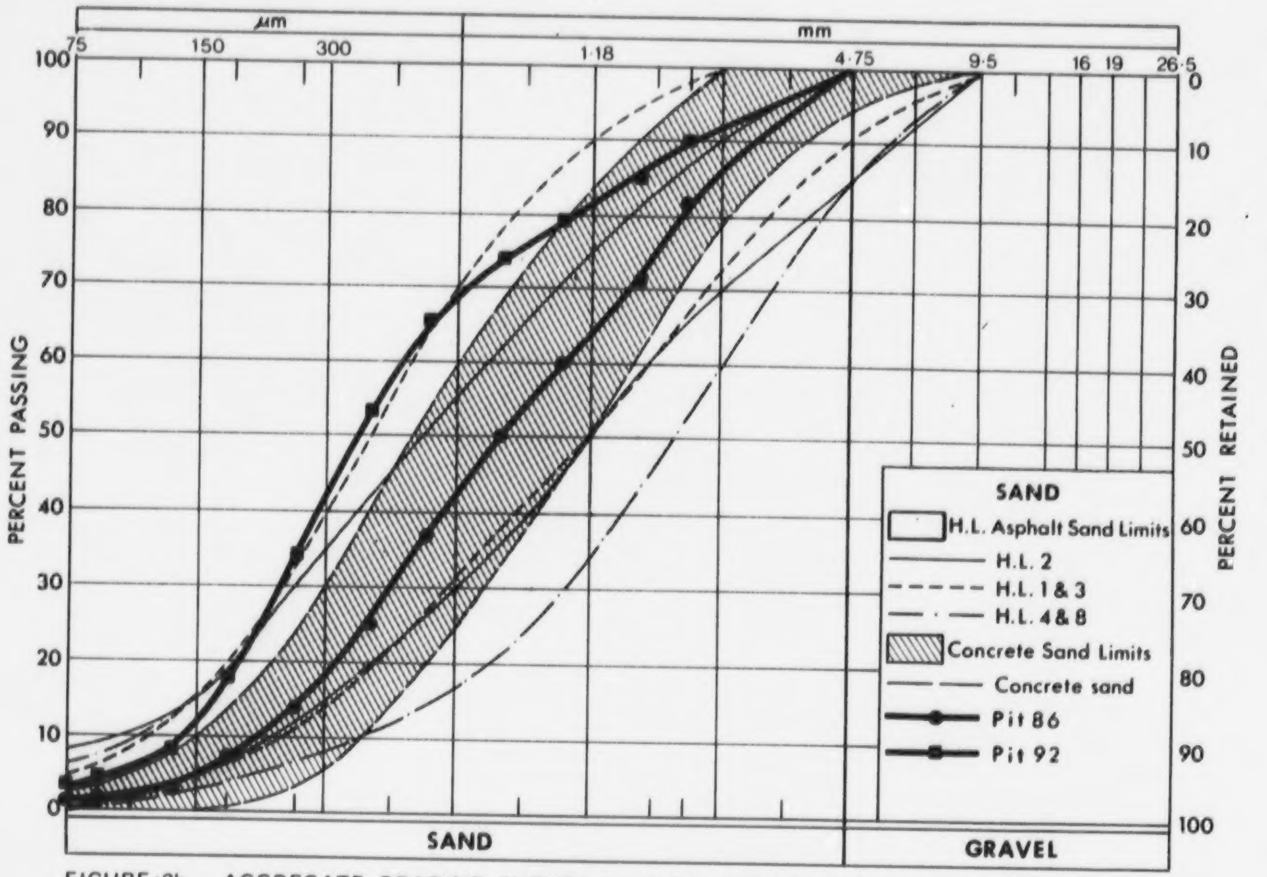

FIGURE:8b AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, DISTRICT OF ALGOMA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

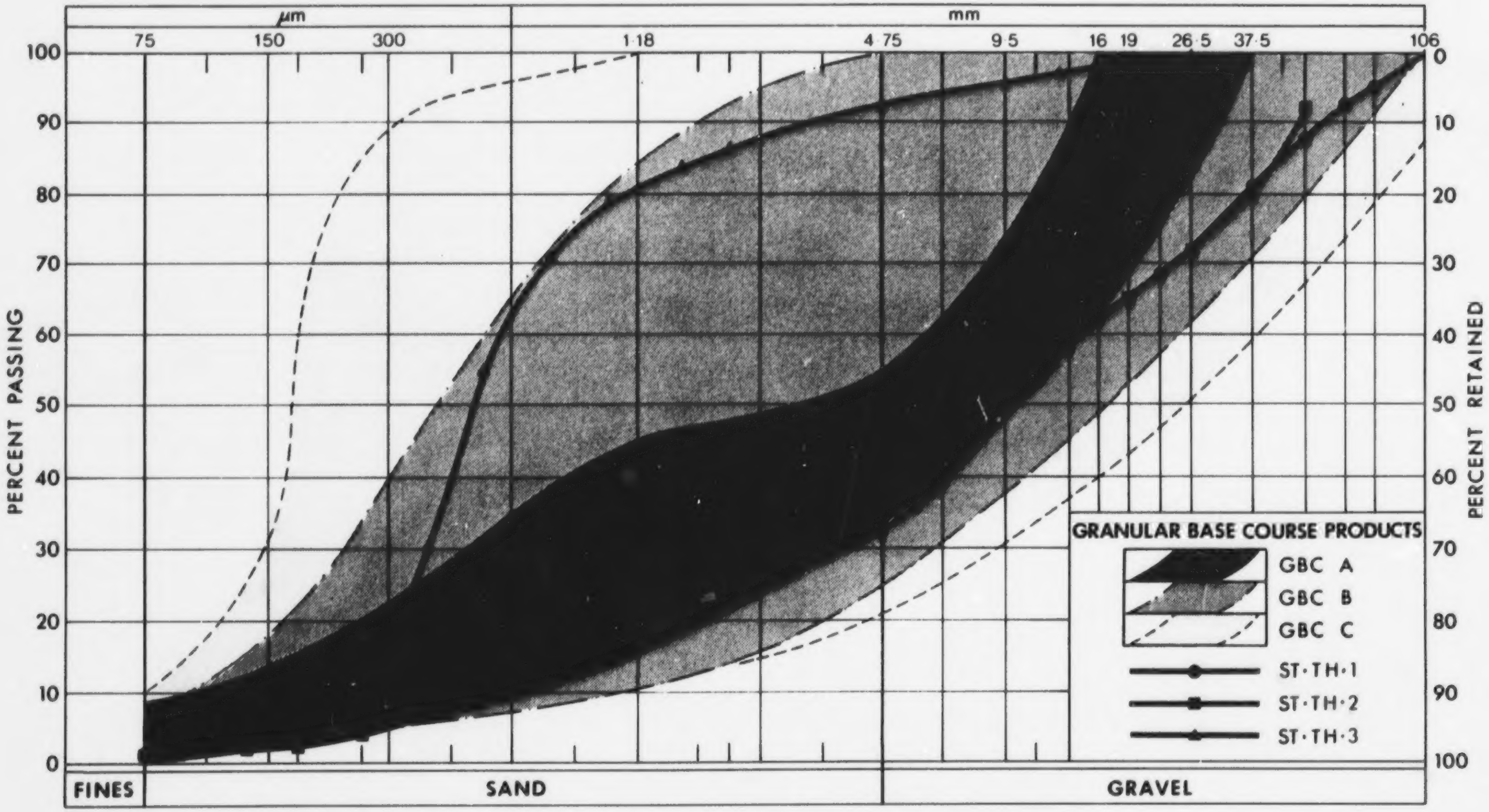

FIGURE :9a AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

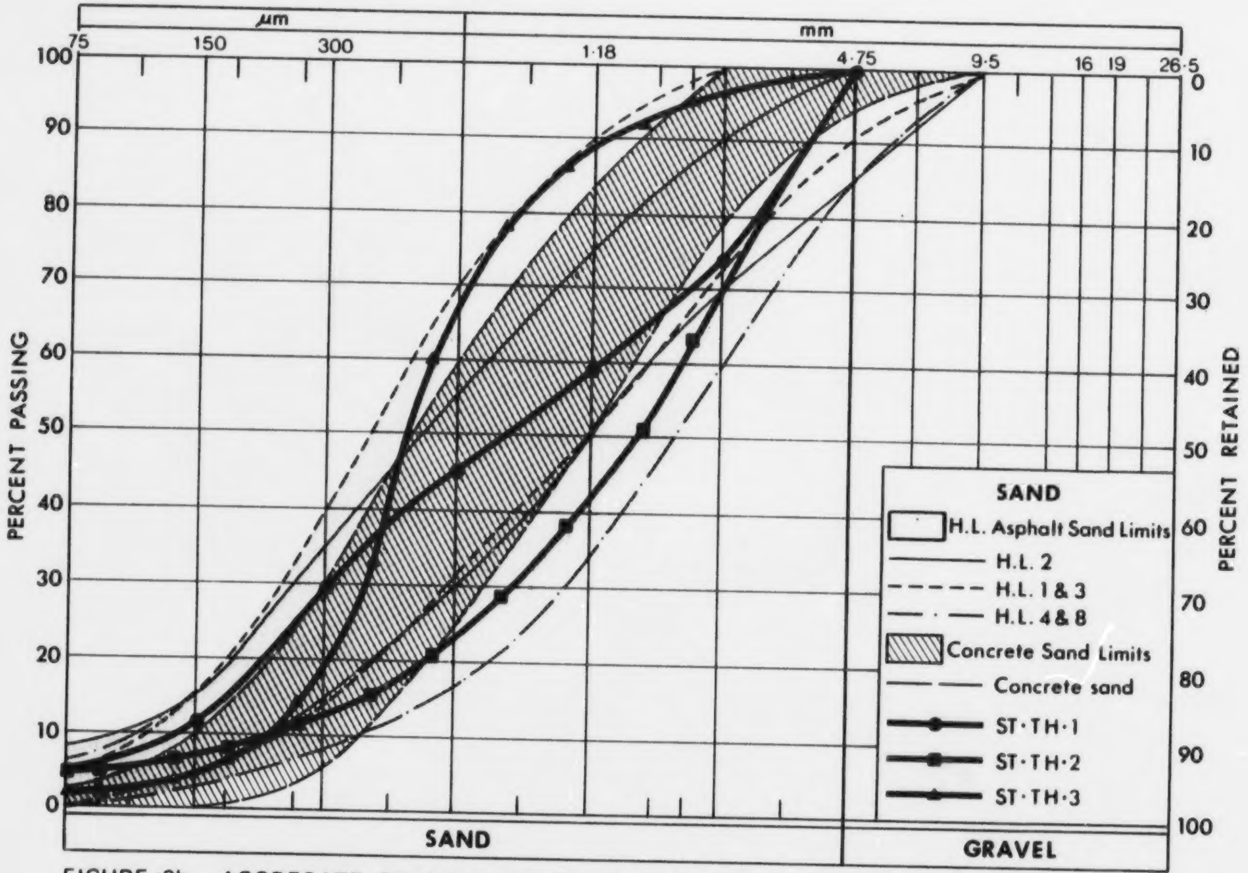

FIGURE :9b AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, DISTRICT OF ALGOMA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

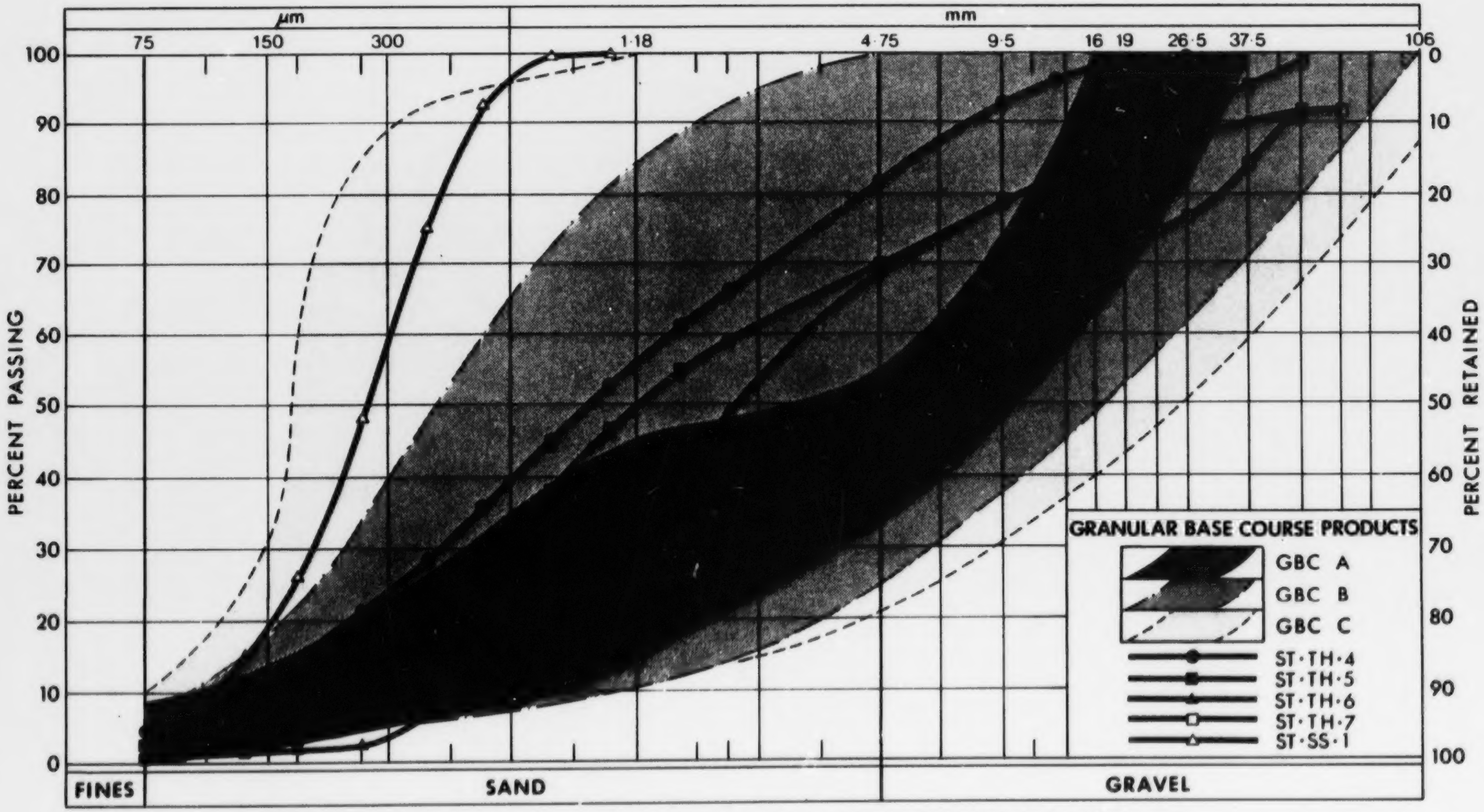

FIGURE :10a AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

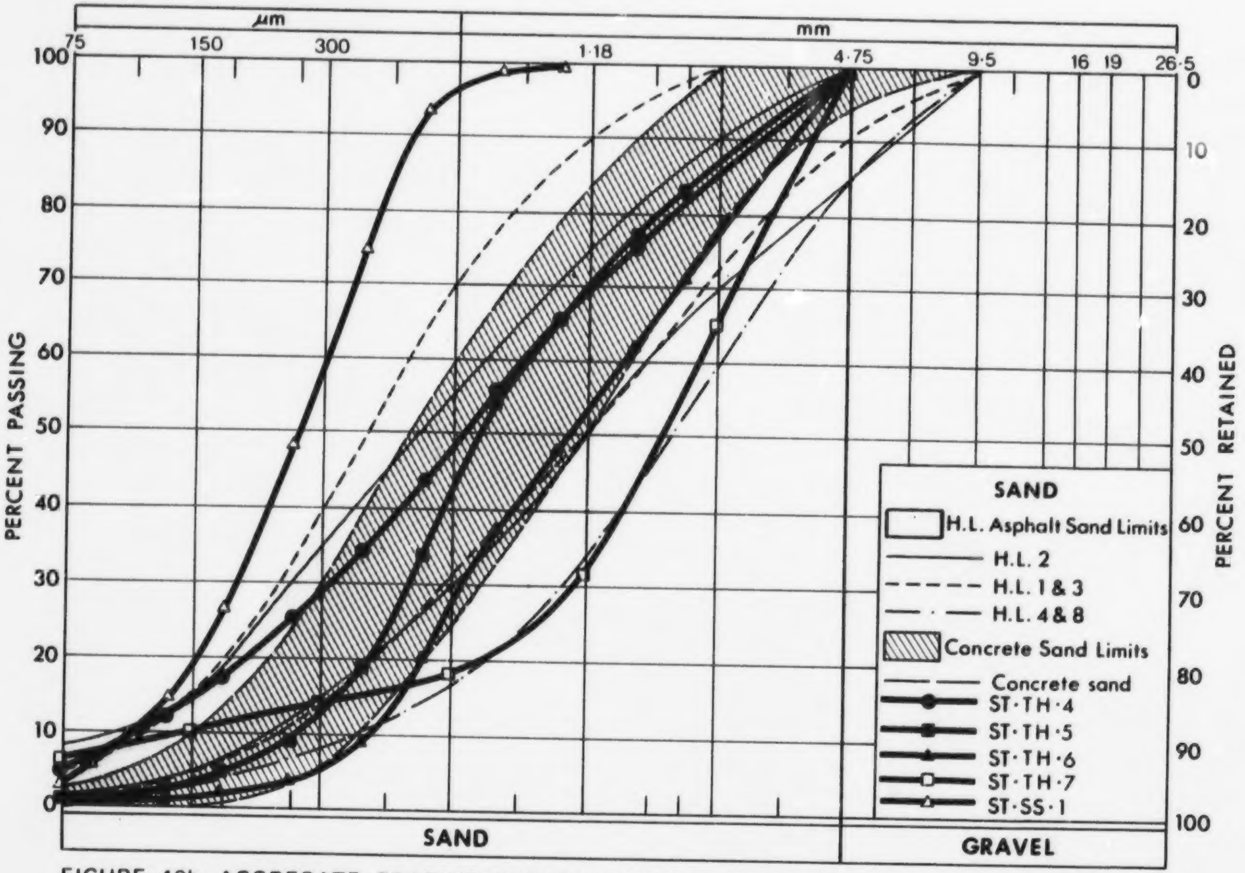

FIGURE :10b AGGREGATE GRADING CURVES, ECHO BAY-BRUCE MINES AREA, **DISTRICT OF ALGOMA;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

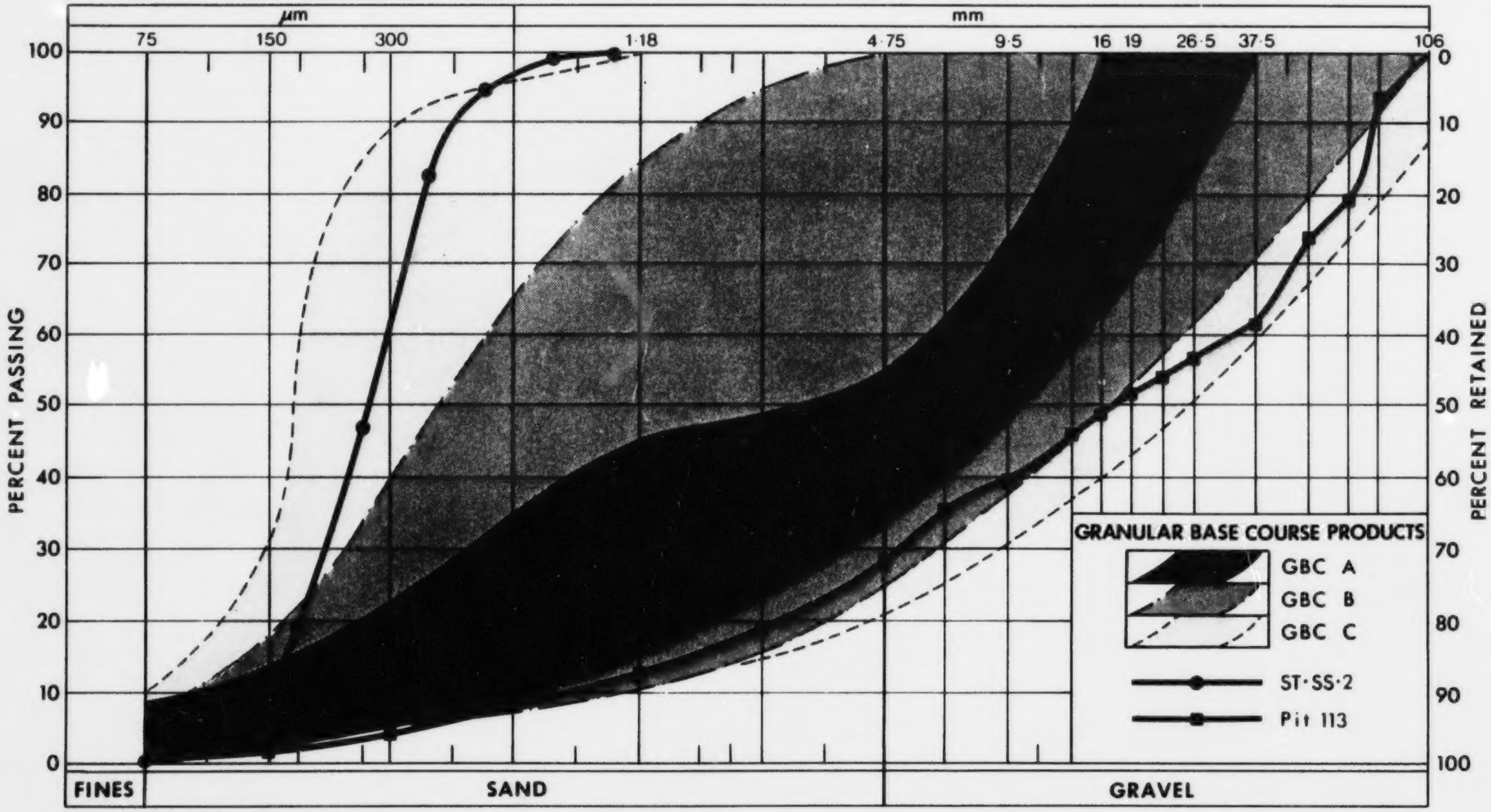

FIGURE :11a AGGREGATE GRADING CURVES, ST JOSEPH ISLAND, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

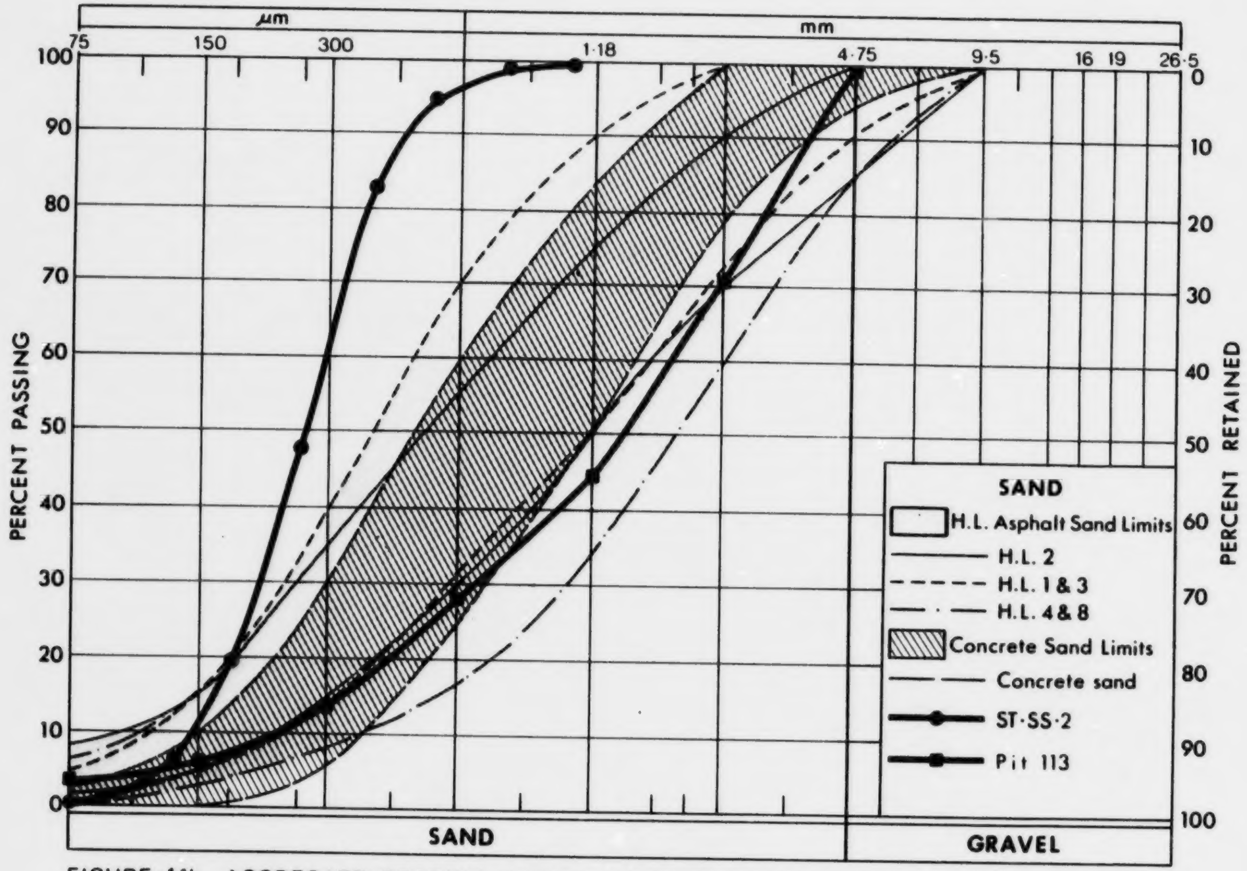

FIGURE : 11b AGGREGATE GRADING CURVES, ST JOSEPH ISLAND, **DISTRICT OF ALGOMA;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

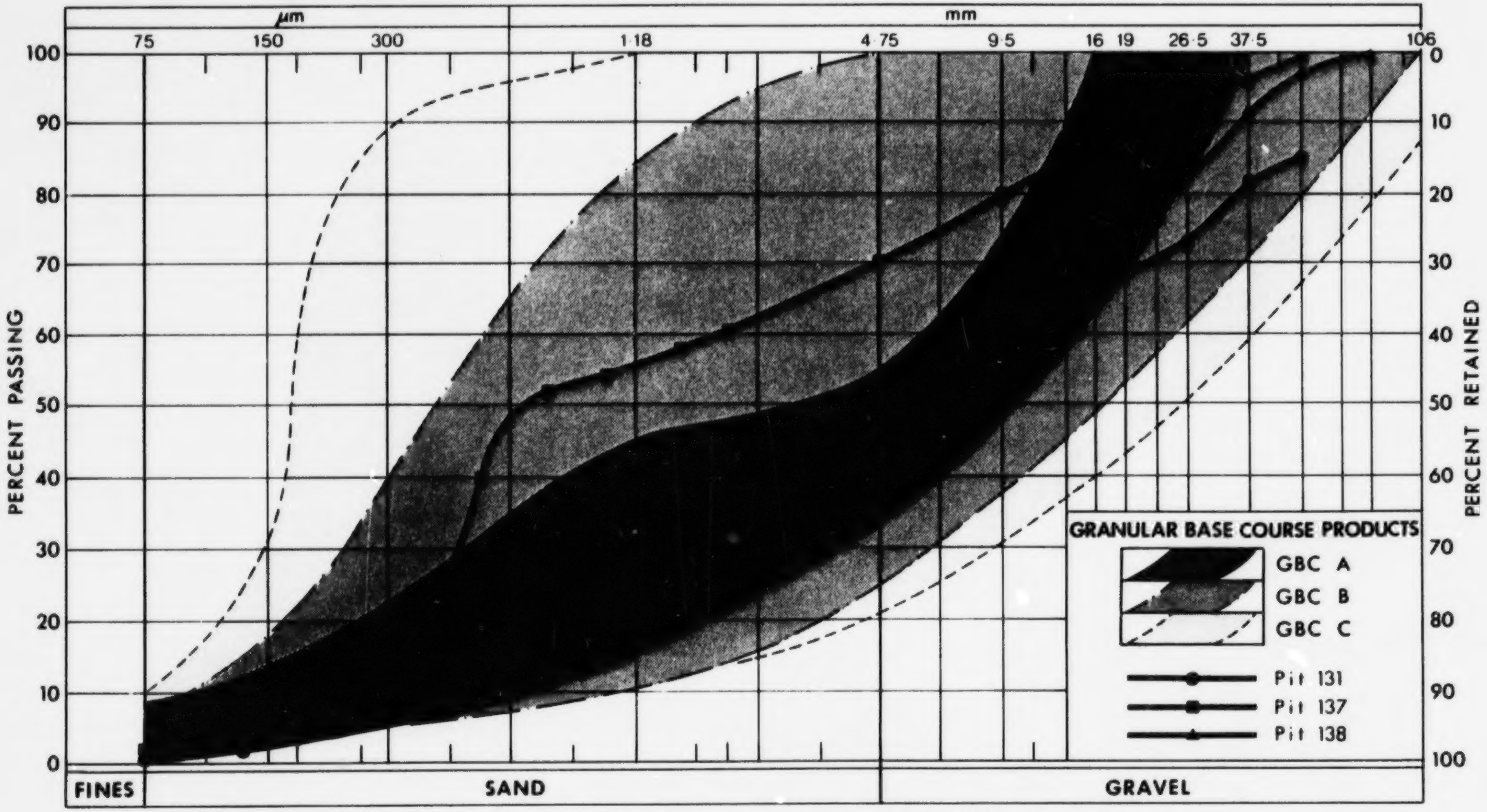

FIGURE :12a AGGREGATE GRADING CURVES, ST JOSEPH ISLAND, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

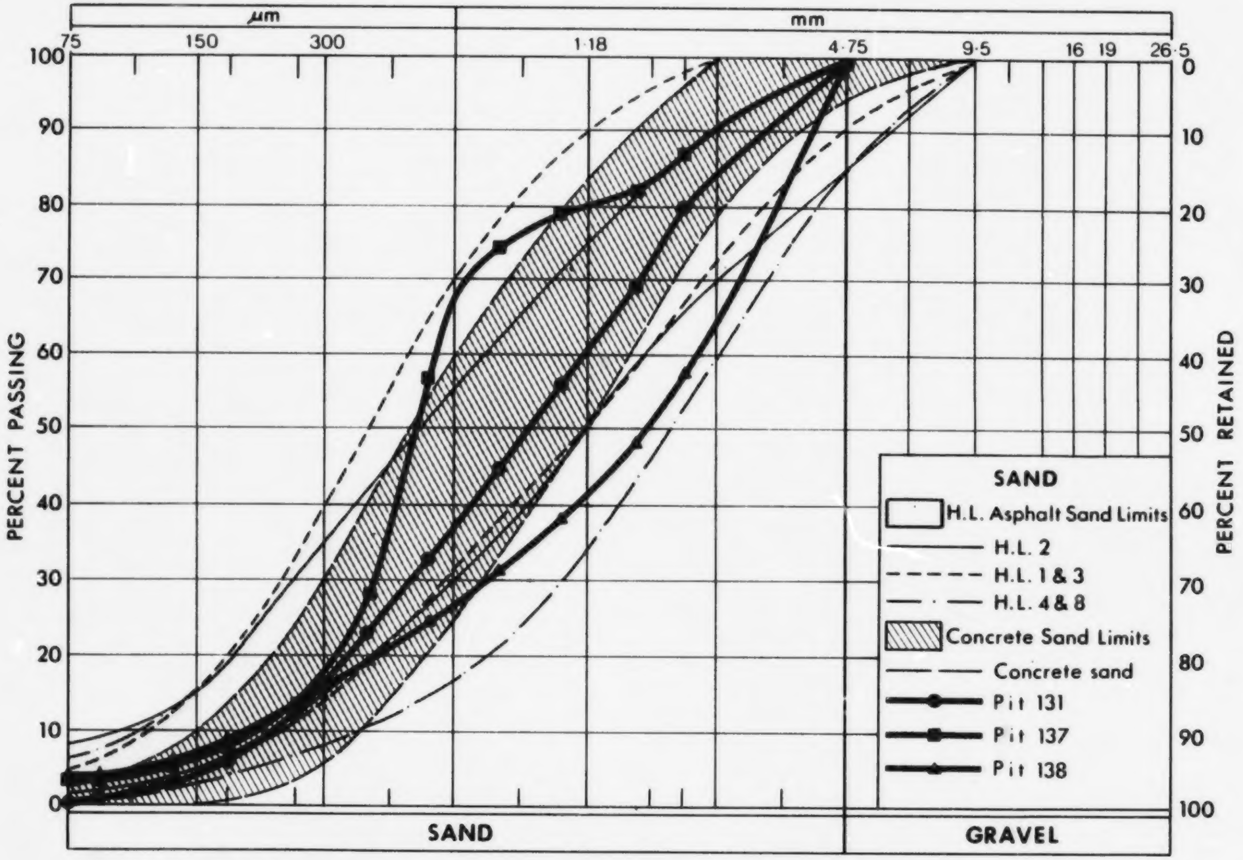

FIGURE :12b AGGREGATE GRADING CURVES, ST JOSEPH ISLAND, DISTRICT OF ALGOMA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

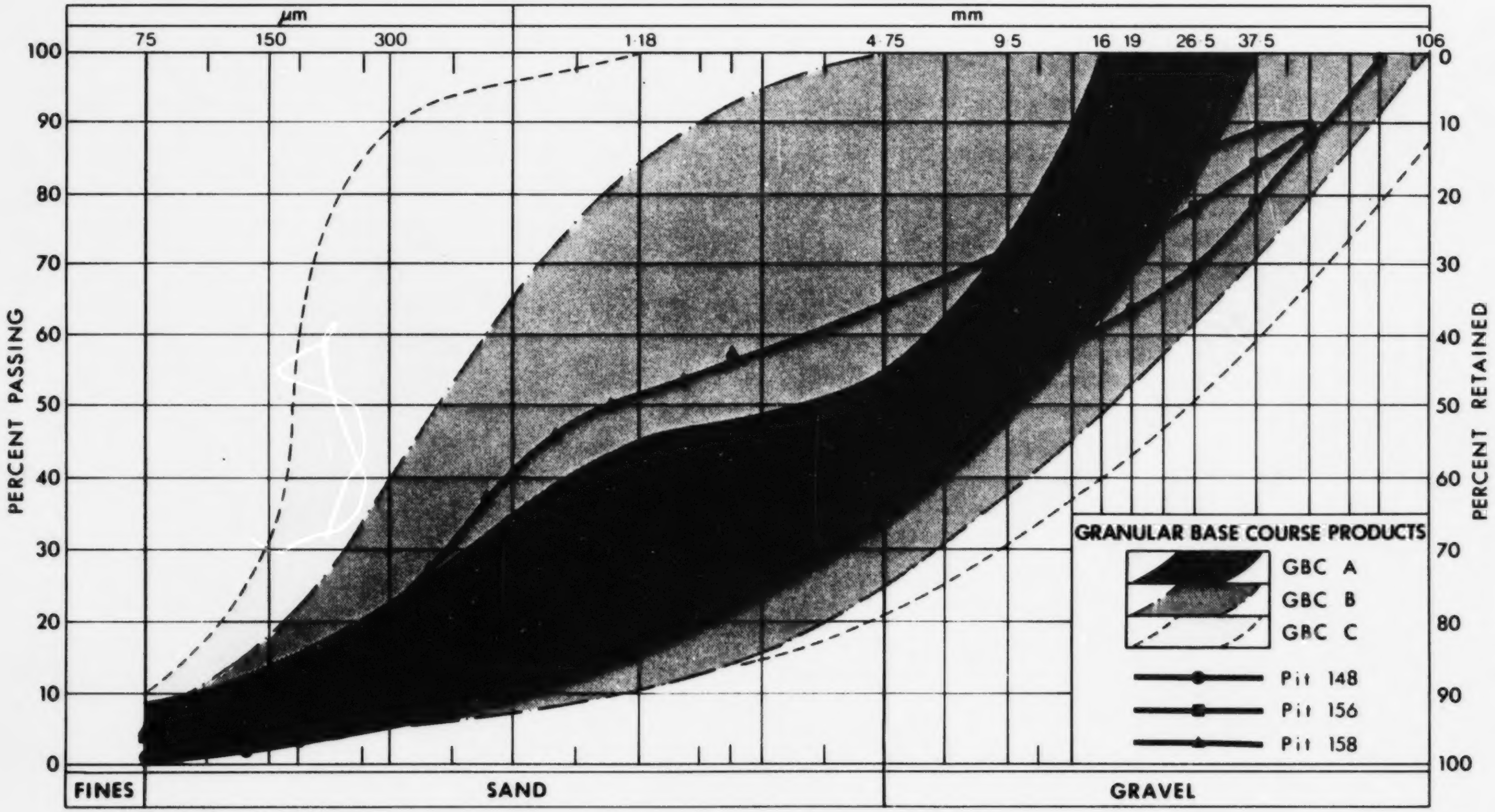

FIGURE :13a AGGREGATE GRADING CURVES, ST JOSEPH ISLAND, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

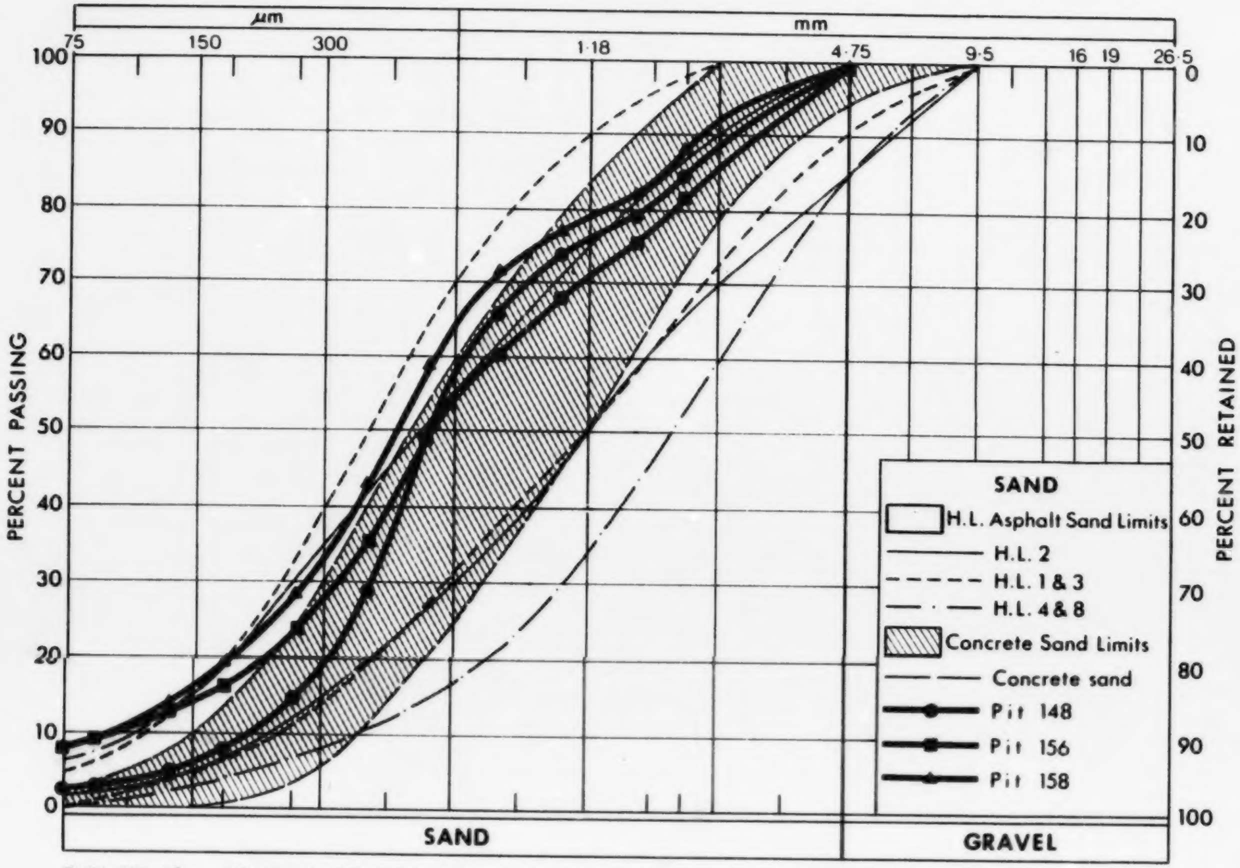

FIGURE :13b AGGREGATE GRADING CURVES, ST JOSEPH ISLAND, **DISTRICT OF ALGOMA;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

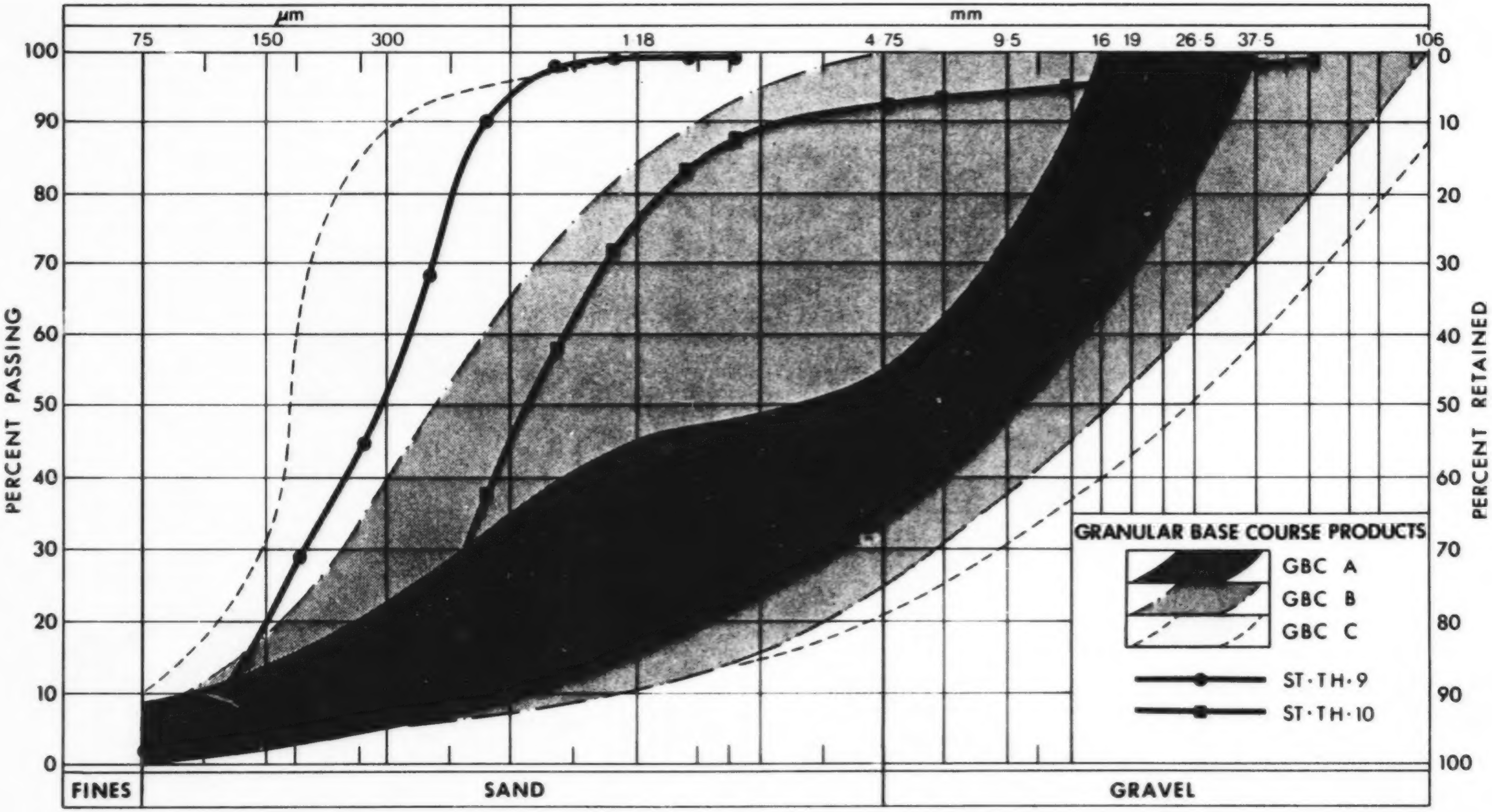

FIGURE :14a AGGREGATE GRADING CURVES, ST JOSEPH ISLAND, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

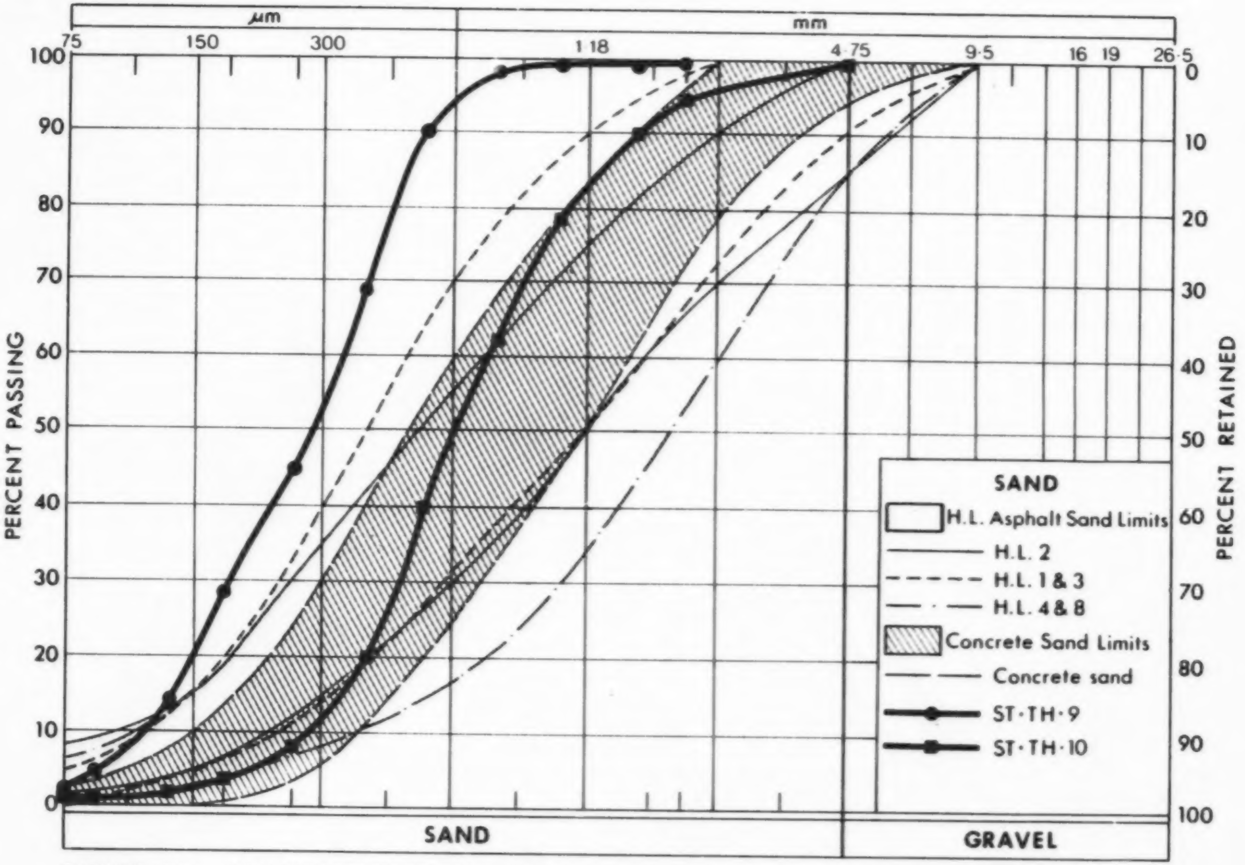

FIGURE : 14b AGGREGATE GRADING CURVES, ST JOSEPH ISLAND, **DISTRICT OF ALGOMA;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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APPENDIX A - PURPOSE, METHODOLOGY AND DATA PRESENTATION OF THE AGGREGATE RESOURCES INVENTORY*

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1984, the total tonnage of mineral aggregate extracted was 109 million tons (99 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Weatherson 1986).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where the deposits occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of the deposit is a function of its proximity to a market area, as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons, the availability of adequate resources for future development is now being threatened in some areas.

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* **This Appendix is made up of the standard Introduction and Part I and II from the Aggregate Resources Inventory Paper (A.R.I.P.) series (for example, see A.R.I.P. 140, Aggregate Resources Inventory West of Sudbury. The text has been modified slightly to correspond to the data presented in this Open File Report. The methodology and data presentation used in this OFR are identical to those used in the A.R.I.P. Series.**

Comprehensive planning and resource management strategies are required to make the best use of available resources. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of the resources.

The report includes an assessment of all the sand and gravel resources in the study area. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report involved the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References), as well as field examination of potential resource areas. Field methods included the examination of natural and man-made exposures of granular material. Observations were made at sand and gravel pits located from records held by the Ontario Ministry of Transportation, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations of the shape and lithology of the particles were also made. These characteristics are important in estimating the quality and quantity of the aggregate. Aerial photographs were used to determine the continuity of deposits, especially in areas for which only limited information was available.

Deposits with potential for further extractive development or those for which existing data were scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11- to 45-kg) units from existing pit faces. The samples were analyzed for grain size distribution. In areas of limited subsurface exposure, test holes were excavated using a wheeled backhoe. The location of test holes are shown on

Map 1 and test hole data are summarized in Table 4. As well, geophysical surveys were undertaken using a portable hammer seismic unit. The location of geophysical traverse lines are shown on Map 1 and the geophysical data are summarized in Table 5.

The field data were supplemented by pit information on file with the Engineering Materials Office of the Ontario Ministry of Transportation. Data contained in these files include field estimates of the depth, composition and "workability" of deposits. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The locations of additional aggregate sources were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were referred to at the preliminary assessment stage to identify areas of possible buried granular material. These records were used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The base map was prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

Sand and Gravel Resources

Once the interpretative boundaries of the aggregate units have been established, quantitative estimates of the possible available resources can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3-m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage - Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted. The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factory (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection (Column 7).

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however, the aggregate potential of these deposits is discussed in the report.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent for the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel are termed possible resources (see Glossary, Appendix C) in accordance with terminology of the Ontario Resources Classification Scheme (Robertson 1975, p. 7) and with the Association of Professional Engineers of Ontario (1976).

PART II - DATA PRESENTATION AND INTERPRETATION

There are two maps, each portraying a different aspect of the aggregate resources in the report area. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

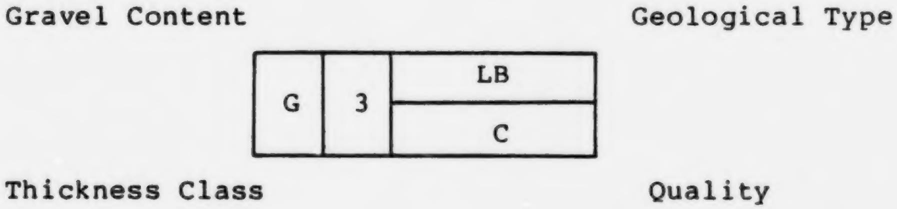
Map 1 is derived directly from existing surficial geology maps of the area or from aerial photograph interpretation in areas where mapping is incomplete. The map represents a comprehensive inventory of sand and gravel deposits within the project area and serves as a base for the calculation of total sand and gravel resources.

On the map, all sand and gravel deposits are outlined and shaded. The present level of extractive activity in the area is also indicated. All known sand and gravel pits, whether presently active or inactive, are shown by a dot symbol and a number which refers to the pit descriptions given in Table 2. Each description notes the location of the pit and the estimated face height and gravel content. In addition, test hole locations appear on Map 1 as a point symbol, and test hole logs appear in Table 4. Geophysics lines are shown on Map 1 by a line symbol and are interpreted in Table 5.

The map also represents a summary of all available information related to the quality of aggregate in the mapped deposits. Much of this information is contained in two symbols which appear on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

Deposit Symbol

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies a lacustrine beach deposit 5 to 10 feet (1.5 to 3 m) thick containing more than 35 percent unprocessed gravel. Excess fines may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. The "G" indicates that the deposit probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the deposit types are summarized with respect to their main geologic and extractive characteristics in Appendix D) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed under "Aggregate Quality" in the next section.

Texture Symbol

The Texture Symbol provides a more detailed assessment of the grain size distribution of material sampled during field study. These symbols are derived from the information plotted on the aggregate grading curves found in the report. The relative amounts of gravel, sand, and fines in the sampled material are shown graphically in the Texture Symbol by the subdivision of a circle into proportional segments.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary and tertiary. These areas are identified on Map 2 by different levels of shading. Each area of primary significance is given a deposit number and all such deposits are shown by a dark tone on Map 2.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of an official plan.

Deposits of secondary significance are indicated by a light tone on Map 2. These deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas, they may contain large quantities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line, but have no tone. They are neither rated nor considered to be important resource areas, because of their low available resources or because of possible difficulties in extraction. Such areas may be useful for local needs, but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the project area. Generally, Class 1 deposits, [greater than 20 feet (6 m) thick] containing more than 35 percent coarse aggregate larger than the No. 4 (4.75 mm) sieve are considered to be the most favourable for commercial development. Thinner deposits may be valuable in areas with low total resources.

Aggregate Quality

The limitations of natural aggregate for various uses result from variations in the lithology of the particles making up the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the deposit symbols. They are: Gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the quality indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent aggregate larger than the No. 4 (4.75 mm) sieve, and also a minimum of 20 percent larger than the 1 inch (25 mm) sieve, are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess "fines" (high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent "oversize" material [greater than 4 inches (10 cm) in diameter] may also have use limitations. The oversize component is unacceptable for all concrete and road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

Another indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit symbol indicates either "C", "O", "L" or any combination of these indicators, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt is made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and the Engineering and Terrain Geology Section of the Ontario Geological

Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes or pits are plotted on grain size distribution graphs. On the graphs are the Ministry of Transportation's gradation specification envelopes for aggregate products: Granular Base Course (G.B.C.) A, B, and C; and Hot-Laid (H.L.) Asphaltic Sand Nos. 1, 2, 3, 4, 5, 6 and 8. By plotting the grading curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the gradation criteria for each product. These graphs, called aggregate grading curves, follow the tables in the report.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the appropriate Ontario Ministry of Natural Resources District Office.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns. The aggregate resources in the region surrounding a project area should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, an area that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Areas with high resources in proximity to large demand centres are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

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APPENDIX C - GLOSSARY

ABRASION RESISTANCE: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

AGGREGATE ABRASION VALUE: This test directly measures the resistance of aggregate to abrasion with silica sand and a steel disk. The higher the value, the lower the resistance to abrasion. For high quality asphalt surface course uses, values of less than 6 are desirable.

ALKALI-AGGREGATE REACTION: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BENEFICIATION: Beneficiation of aggregates is a process or combination of processes which improves the quality (physical properties) of a mineral aggregate and is not part of the normal processing for a particular use, such as routine crushing, screening, washing, or classification. Heavy media separation, jigging, or application of special crushers (e.g. "cage mill") are usually considered processes of beneficiation.

BLENDING: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

BULK RELATIVE DENSITY: An aggregate with low relative density is lighter in weight than one with a high relative density. Low relative density aggregates (less than about 2.5) are often non-durable for many aggregate uses.

CLAST: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DOLOSTONE: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GLACIAL LOBE: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in Ontario.

GRADATION: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANULAR BASE COURSE: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

LOS ANGELES ABRASION AND IMPACT TEST: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported, and placed. Values less than about 35 percent indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45 percent indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

MAGNESIUM SULPHATE SOUNDNESS TEST: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible to freezing and thawing will usually break down and give high losses in this test. Values greater than about 12 to 15 percent indicate potential problems for concrete and asphalt coarse aggregate use.

MELTWATER CHANNEL: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION: Individual aggregate particles in a sample are divided into the catagories good, fair, poor, and deleterious, based on their rock type (petrography) and knowledge of past field performance. A petrographic number (PN) is calculated. The higher the PN, the lower the quality of the aggregate.

PLEISTOCENE: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POLISHED STONE VALUE: This test measures the frictional properties of aggregates after 6 hours of abrasion and polishing with an emery abrasive. The higher the Polished Stone Value (PSV), the higher the frictional properties of the aggregate. Values less than 45 indicate marginal frictional properties, while values greater than 55 indicate excellent frictional properties.

POSSIBLE RESOURCE: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN: The earliest geological period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SHALE: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

SILURIAN: An early period of the Palezoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX D - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuties. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC)

This designation may include deposits from several ice-contact depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Alluvium (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probabiltiy of locating crushable aggregate in windblown deposits is very low.

3268
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